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Carnivore Studies in the Pioneer Mountains and Adjacent Mountain Ranges of Southwest Montana

Final Report
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Introduction

The Rocky Mountain Research Station(RMRS), in cooperation with the Western Federal Lands Highway Division of the Federal Highway Administration (WFLHD), initiated a 3-year study in 2000 to assess the direct and indirect impacts of road improvements to the Pioneer Mountains Scenic Byway on lynx and other forest carnivores. Other wildlife, such as ungulates and prey species of lynx, were also surveyed. Contractual requirements (WFLHD Agreement Number: 00-A-17A0031) have included the filing of annual reports each year to summarize field activities and research findings, as well as the completion of this final report. In this report, we present the original objectives of the study, changes in these objectives due to preliminary findings, final research results, and a discussion of these results as they affect the Pioneer Mountains Scenic Byway Project.

Project Overview and Objectives

This study was developed in response to a lawsuit filed by the Native Ecosystems Council regarding the potential effects of the Pioneer Mountains Scenic Byway reconstruction project on the resident population of Canada lynx (*Lynx canadensis*) in the Pioneer Mountains. The environmental assessment completed for the project concluded that proposed improvements would expand the "zone of human influence" along the entire length of the byway and into the backcountry of the Pioneer Mountains. Because the Canada lynx was listed as a threatened species subsequent to the 1996 environmental assessment, the plaintiff argued that WFLHD should review their analysis to determine the effects that increased motorized and non-motorized human activity could have on lynx. In response to a federal court ruling, WFLHD decided to mitigate their work by not paving phases 2 and 3 of the road improvement, which stretch from Grasshopper Creek to the Forest Boundary and on to Price Creek in the southern Pioneers. Although WFLHD was interested in paving the remaining sections of the Byway, no paving was to occur without concurrence by the United States Fish and Wildlife Service (USFWS). This study was initiated to serve as further mitigation regarding the improvements and to attempt to address the plaintiff's concerns.

Although roads clearly impact some species of wildlife, the results cannot be generalized to Canada lynx. We know that lynx are capable of long-distance dispersal >100 km (Ward and Krebs 1985, O'Donoghue et al. 1995, Slough and Mowat 1996) and these movements may be critically important for maintaining lynx populations, especially in island mountain ranges. However, we do not know how vegetation patterns or landscape physiography affect where lynx and other forest carnivores cross transportation corridors nor to what extent corridor development inhibits crossing. Furthermore, the secondary impacts associated with roads, such as increased human activity, remain unknown.

From 1977 to 1994, 39 lynx occurrences were recorded in the Pioneer Mountains, including 13 harvested individuals (McKelvey et al. 2000). Snow-track surveys performed as recently as 2000 indicated that lynx were present along the Scenic Byway (Forkan 2000). However, beyond track sightings and harvest records, information regarding lynx distribution and abundance throughout the Pioneers and adjacent ranges was limited and insufficient for formulating management decisions. As a result, WFLHD requested that we investigate the following objectives:

1. How many lynx use the project and surrounding area?
2. Do lynx use the project and surrounding area for foraging, denning, or both?
3. How might a paved vs. a gravel road surface affect lynx movements and use?
4. What level of traffic volume (ADT) begins to affect how lynx move through or use an area?
5. Is there a particular place along the project that lynx use to cross the road?

Rigorous winter snow track surveys were conducted as a first step during the winter of 2001 to determine the presence and distribution of lynx. Surprisingly, only a single lynx track was documented throughout the three mountain ranges. Although data show that lynx were historically present in the area, the area did not support a resident population at the time of our first survey. The fact that lynx existed at exceedingly low densities made it impossible for us to address the remaining objectives. As a result, we consulted with WFLHD regarding the situation. Since we had documented 36 wolverine detections during 2001, and given that wolverine are highly mobile animals that are considered sensitive to human disturbance (Banci 1994), we decided to focus on this species to address movement and transportation corridor

issues while still continuing surveys for lynx on the project area. As a result, we revised our objectives to:

1) Determine the distribution of wolverine, lynx, and other carnivores in the Pioneer Mountain Range and adjacent ranges.
2) Determine the location and relative frequency that wolverine, lynx, and other wildlife species use or cross the Byway based on winter snow tracks.
3) Determine if environmental correlates such as vegetation structure and composition, elevation, and landscape physiography are useful to predict where wolverine, lynx, and other wildlife species cross the Byway.
4) Determine how wolverine and lynx home range configurations, movements, and dispersal relate to the Byway and other travel corridors on both a landscape and fine spatial scale.
5) Determine habitat selection preferences of wolverine den sites relative to human activity.

Study Area

Research activities occur within three mountain ranges in southwest Montana: the Pioneers, Anaconda-Pintlers, and Flint Creek mountains (Figure 1). Due to our focus on studying the Pioneer Mountains Scenic Byway, our research activities were more heavily weighted towards the Pioneer area. The Pioneer Mountains are located south of the Big Hole River and are bounded to the east by Interstate 15 and State Highway 43 to the north and west. Elevations range from approximately 1,830 m (6,000 ft.) to 3,350 m (11,000 ft.) for the highest peaks located in the eastern portion of the range. The dominant forest cover for the Pioneer Mountains is lodgepole pine (*Pinus contorta*). Lodgepole pine gives way to Douglas-fir (*Pseudotsuga menziesii*) and sagebrush (*Artemisia spp.)* steppe at lower elevations and on south-facing slopes. Mixed Engelmann spruce (*Picea engelmanni*) / subalpine fir (*Abies lasiocarpa*) forests are found on wet aspects at higher elevations. Whitebark pine (*Pinus albicaulis*) occurs at the highest elevations near timberline. Riparian communities are dominated by willow (*Salix spp.*) that often transition into sagebrush dominated meadows.

The Anaconda-Pintler and Flint Creek mountains are located to the north and west of the Pioneers and are in close proximity to the project in terms of animal movements. Habitat types

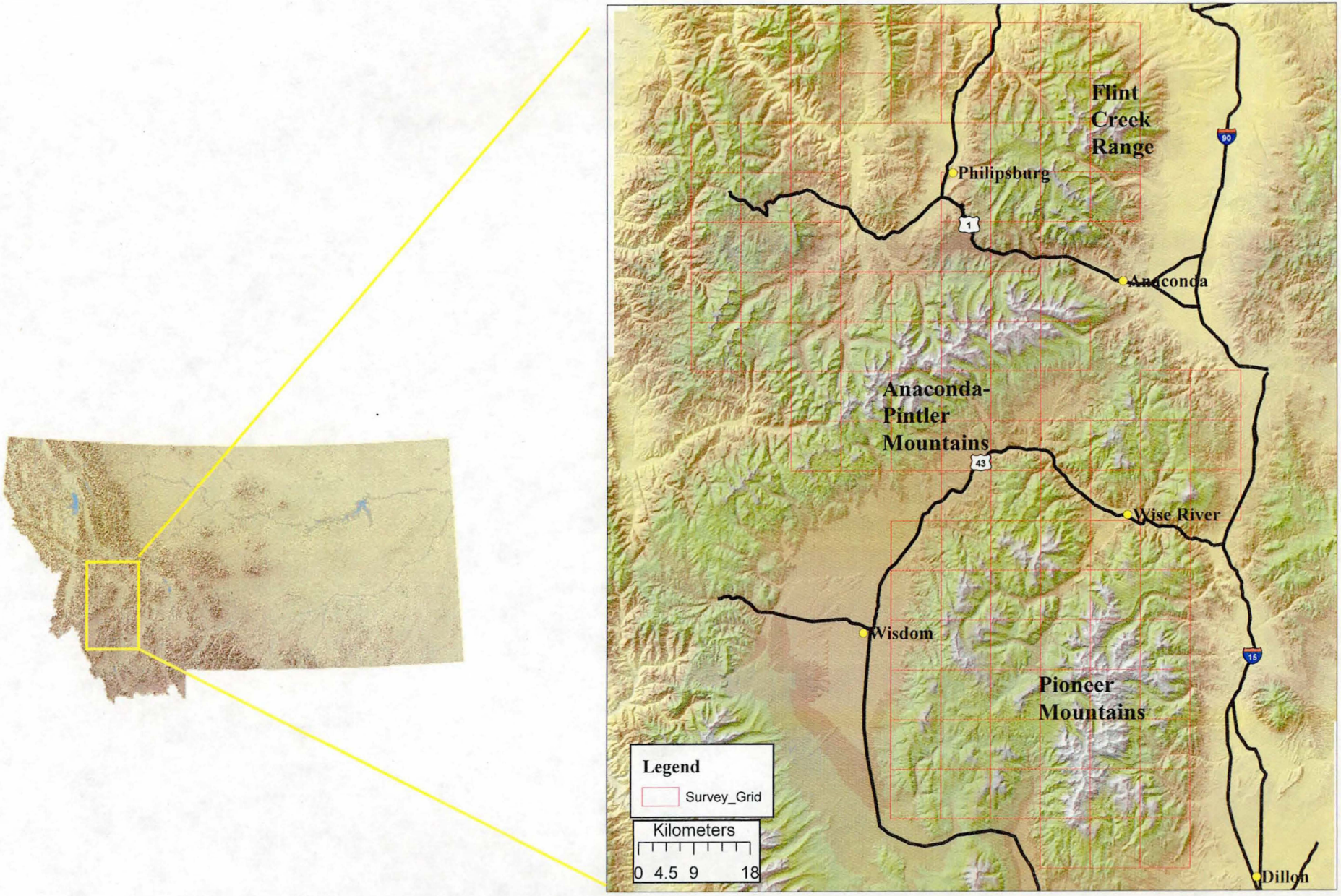

Figure 1: Map of survey grid and study area, including the Pioneer, Anaconda-Pintler, and Flint Creek mountain ranges, in southwestern Montana.

in these ranges are similar to those in the Pioneers, although sagebrush openings are less common due to more mesic conditions. Higher elevations are dominated by mixed subalpine forests changing to lodgepole pine at mid-elevations on most aspects. Douglas-fir is found on dry sites at lower elevations.

Methods to Address Objective #1: *Determine the distribution of wolverine, lynx, and other carnivores in the Pioneer Mountain Range and adjacent ranges.*

We developed a rigorous survey protocol to survey the entire Pioneer mountain range, as well as portions of the Anaconda-Pintler and Flint Creek ranges. To achieve a representative survey, we overlaid a grid across the study area, with each pixel measuring 8 km^2 (4.9 mi^2) (Figure 1). We selected a survey unit of this pixel size based on an average female home range for lynx at Seeley Lake (Squires and Laurion 1999). The size of our sample unit was small enough to reduce the chance of missing a lynx, but large enough to provide an efficient survey across extensive landscapes. Our minimum sample effort within each survey unit was 10 km (6.2 mi) in suitable habitat. Most surveys were conducted by traveling roads and trails by snowmobile. In areas that precluded snowmobile access, we searched for tracks on snowshoes.

We conducted both *intensive* and *extensive surveys. Intensive surveys* were conducted over 10 km within each survey unit, and data from these surveys were logged directly into a Trimble GeoExplorer 3 GPS unit. Technicians collected data regarding habitat type, stand structure, travel route, snow conditions, track locations for forest carnivores, and weather conditions along the entire survey route. Logging the data directly into the GPS ensured that we accurately mapped all survey routes and associated data, so that researchers in the future could replicate the survey if needed. Each time technicians entered a new stand type, they logged the land cover type, overstory species composition, overstory size class, and stand structure. Habitat changes were noted whenever they covered more than two ha (5 acres) or were greater than 100 m (328 ft) along the route.

We recorded all wolf (*Canis lupus*), coyote (*Canis latrans*), mountain lion (*Puma concolor*), lynx, bobcat (*Lynx rufus*), wolverine (*Gulo gulo*), fisher (*Martes pennanti*), and marten (*Martes americana*) tracks detected during the survey. Attributes describing the species,

track condition, ID certainty, measurements, and use of packed snow were logged directly into the GPS to ensure all data were correctly logged and spatially referenced. Multiple crossings of the same species within 100m (328 ft) were not recorded as new hits, but the animal's use of the snow track (i.e. crossing, on snow track<100m, etc.) was logged. All tracks of lynx, wolverine, mountain lion, bobcat, fisher, and wolf that were observed in the survey unit were recorded and photographed regardless of whether or not the track crossed the survey route. We measured all tracks (length, width, depth in snow, snow depth in track, stride, straddle, and gait) to verify our track identifications. For common species, such as marten and coyote, we only measured every fifth track that was encountered or when unusual tracks or gaits were observed. To facilitate comparison of prey abundances across areas with very different snow deposition, we only counted track crossings of red squirrels and snowshoe hares between 24 and 72 hours after a snow event. Outside of this survey-window we only documented the presence/absence of prey.

Extensive surveys did not record environmental attributes of the survey routes, but focused strictly on recording track detections for lynx, wolverine, fisher, mountain lion, bobcat, and wolf. As with the *intensive surveys*, tracks of these species were photographed and measured, but no habitat, prey, or common forest carnivores were recorded. *Intensive* and *extensive surveys* were designed to compliment each other when done simultaneously to ensure that detailed habitat data were collected while also allowing for large areas to be surveyed.

Methods to Address Objective #2: *Determine the location and relative frequency that wolverine, lynx, and other wildlife species use or cross the Byway based on winter snow tracks.*

To specifically address the issue of wildlife interaction with the Scenic Byway, we conducted snow track surveys along the road from Pattengail Trailhead to Elkhorn Resort, which is the portion of the road closed to wheeled vehicles during winter months. Surveys were designed to occur during the period 24 to 72 hours after a snowfall. This time window was an attempt to ensure tracks were fresh enough to be identified while also providing adequate time for animals to interact with the road after a snowstorm. We used the same data logging procedures along the Byway that we used for *intensive surveys* for documenting species detections, including ungulates.

Methods to Address Objective #3: *Determine if environmental correlates such as vegetation structure and composition, elevation, and landscape physiography are useful to predict where wolverine, lynx, and other wildlife species cross the Byway.*

Winter crossings of wildlife on the Byway were analyzed by species to identify habitat differences at crossing points. Crossing locations were compared to habitat types using ArcGIS 8.3. To prevent inconsistencies in habitat identification among field technicians, a final survey of byway habitat was performed by the field coordinator on August 3rd, 2003. This habitat delineation was then merged with 3 field seasons worth of species crossings to produce tables showing all species detections by habitat feature. We analyzed these combined results using Chi-square Goodness-of-Fit tests and Bonferroni confidence intervals (Neu et al. 1974, Byers et al. 1984) to determine if habitat use along the byway occurred in a non-random fashion and to determine which specific landscape components were favored by various species. Because documented wolverine crossings were infrequent, our sample size was insufficient to meet the requirement for using Bonferonni confidence intervals. In addition, we collected anecdotal information that may shed some light on how various wildlife species use the Byway.

In 2002, we backtracked wolverines for 1km at each crossing to determine if they appeared reluctant to cross the road (winter snow-mobile trail) based on track patterns. In other words, did animals approach and cross the road in a steady gait, did they "bounce" away from the road before crossing, or did any other factors appear to affect their crossing? Data regarding animal gait, travel route, slope, and habitat were collected. All movement data were imported into ArcGIS for comparison to digital elevation models, habitat layers, and topography as it relates to both general movements and movements associated with the byway. In addition, we plotted all backtrack routes on satellite photos to provide a visual delineation of wolverine movement adjacent to the road. The small sample of track crossings precluded rigorous statistical analysis of these data.

Understanding the general habitat-use patterns of wolverine is relevant to highway planning. Previous research has shown that high elevation rock and ice habitats are an important component of wolverine habitat use (Magoun and Copeland 1998), although wolverines travel widely and use many types of habitats. Hornocker and Hash (1981) found that wolverines used higher elevation areas during the summer and lower elevation areas during the winter, although the reasons for this difference are could only be hypothesized. To investigate whether

wolverines select for certain elevation zones throughout the year, we divided aerial telemetry into two seasons: Summer (May-October) and Winter (November-April). We determined the range in elevation used during each season, compared the average elevation between seasons, and then used the range to create a layer in ArcGIS that projects the elevation zone across the study area.

Methods to Address Objective #4: *Determine how wolverine and lynx home range configurations, movements, and dispersal relate to the Byway and other travel corridors on both a landscape and fine spatial scale.*

To monitor movements of wide-ranging animals such as lynx and wolverine, animals must be outfitted with either VHF or satellite telemetry. We developed a trapping protocol and constructed 15 log box traps (Figure 2; Copeland et al. 1995) in areas with the highest detection rates as well as areas of historical presence. Traps were outfitted with transmitters that allowed traps to be checked remotely using standard telemetry equipment. Traps were checked remotely at least every two days and physical checks were performed at least every 4th day. During the last month of the trapping season when there is the potential for capturing nursing females, we performed trap checks every morning to reduce the risk to newborn kits.

Figure 2: Log box trap for wolverine capture in Pioneer Mountains, 2002.

Captured animals were implanted with Telonics intraperitoneal IM400™ VHF transmitters and tracked via airplane on a weekly or bi-weekly basis. Relocations collected

during these flights were used to calculate home ranges and to detect large dispersal type movements. However, to better understand movements relative to roads, a more frequent data stream of points is required. We originally intended to use satellite telemetry to monitor movements. By providing multiple relocation points on a daily basis, satellite collars have the potential to better delineate animal movements than weekly telemetry flights. We worked with a collar manufacturer to develop the necessary GPS technology. While no collars were available for the 2001 or 2002 field seasons, we were able to deploy GPS/Argos collars during our 2003 field season.

We calculated minimum convex polygon (Mohr 1947) and kernel home ranges (Worton 1989) using methods via the Animal Movement extension on Arcview 3.2 (Hooge et al. 1999) based on aerial telemetry. While our sample size was inadequate to reach the point of asymptote in calculating home ranges, our estimates are adequate for informing managers of the coarse-scale spatial requirements of wolverine (Seaman et al. 1999).

Methods to Address Objective #5: *Determine habitat selection preferences of wolverine den site selection relative to human activity.*

Road improvements potentially could increase recreation in the Pioneer and adjacent ranges. Improvements in technology have resulted in greater numbers of people accessing backcountry regions to primarily ski and snowmobile. Limited research from Idaho and Canada suggests potentially important overlaps between wolverine reproductive denning habitat and winter recreation (Magoun and Copeland 1998). Although concerns have been raised, no testing has been completed to determine if these activities displace or stress wolverine during this critical time.

The main intent of this objective was to investigate human impacts on denning wolverines by monitoring the movements of female wolverines during the peak denning period (February-May). We recognized that sample sizes would be small and would be limited to anecdotal observations. We intended to document habitat characteristics of den sites and to compare these characteristics to areas randomly available within the animal's home range.

Results

Landscape Surveys

We completed 14,810 km of representative surveys to delineate the distribution of forest carnivores within the Pioneer, Anaconda-Pinter, and Flint Creek ranges (Figure 3) over the course of 3 field seasons. In 2001, we surveyed 1,313 km of *intensive survey* routes. Of the total, 902 km (560 mi) were surveyed in the Pioneer Mountains and the remaining 411 km (255 mi) in the other two ranges. We frequently encountered tracks of coyote (n=1075; Figure 4), marten (n=205; Figure 5), and wolverine (n=36; Figure 7) throughout the survey area. Bobcat (n=10), mountain lion (n=5), and wolf (n=3) were uncommon (Figure 6). Two sets of lynx tracks, apparently from the same animal, were detected in the Anaconda Range (Figure 7)

In addition to *intensive surveys*, we conducted >5000km (3107 mi) of *extensive surveys* across the study area. The lynx tracks we detected (February 12th, 2001) were found on a route at the southern end of the Anaconda-Pintler Mountains. In addition, roughly 33% of all wolverine tracks (n=16) were encountered during these surveys. Wolf, bobcat, and mountain lion tracks were located infrequently.

Surveys continued throughout the 2002 and 2003 field seasons, but were reduced in comparison to 2001 due to the additional time requirement related to wolverine trapping. We completed 585 km and 253 km of *intensive surveys* during 2002 and 2003, respectively. We also completed 1429 km and 919 km of *extensive surveys* during the same 2 seasons. An additional 2111 km and 3200 km of *extensive surveys* were completed along designated trap check routes. No lynx were detected in either 2002 or 2003. Wolverine detections increased in 2002 and 2003 to 115 and 96 (Figure 7), respectively. Bobcat (n=2; n=1), mountain lion (n=13; n=24), and wolf (n=2; n=10) continued to be uncommon in 2002 and 2003 (Figure 6) and were detected mainly in lower elevation areas. Conversely, marten (n=340; n=160; Figure 5) and coyote (n=630; n=256; Figure 4) were common.

The average distance surveyed to detect a wolverine varied by year. In 2001, we detected 36 wolverine tracks during 6,313 km of surveys, for a per-unit-effort of 175 km per detection. In 2002, we had 115 detections during 4,125 km of travel, for a per-unit-effort of 36 km per detection. Lastly, in 2003 we had 96 detections during 4,372 km of travel, for a per-unit-effort of 45.5 km per detection. After the 2002 season, we recognized that the increase in detections was partially due to our traveling standard trap check routes in areas of known wolverine

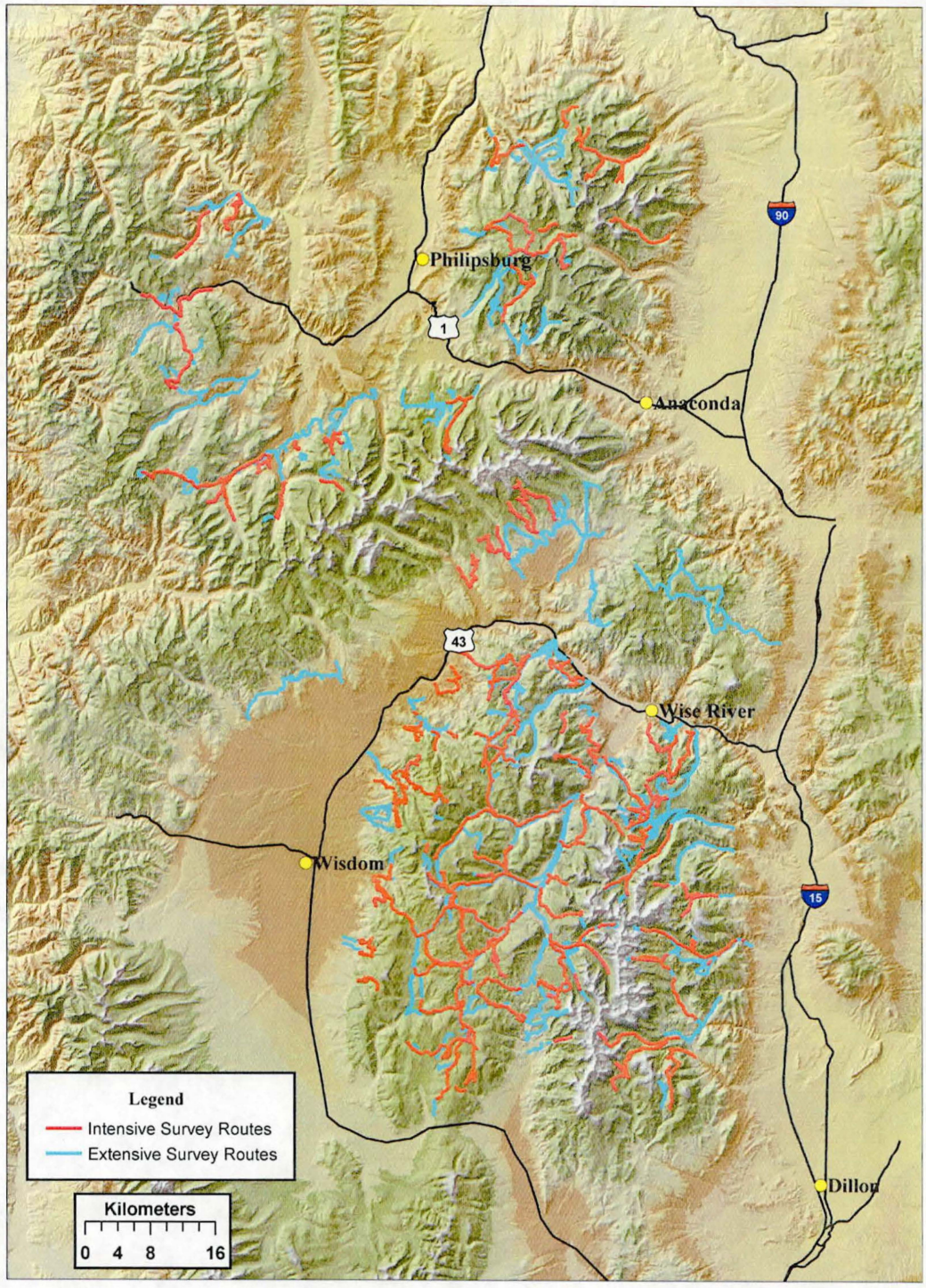

Figure 3: Survey routes completed during 2001, 2002, and 2003 field seasons in the Flint Creek, Anaconda-Pintler, and Pioneer Mountains.

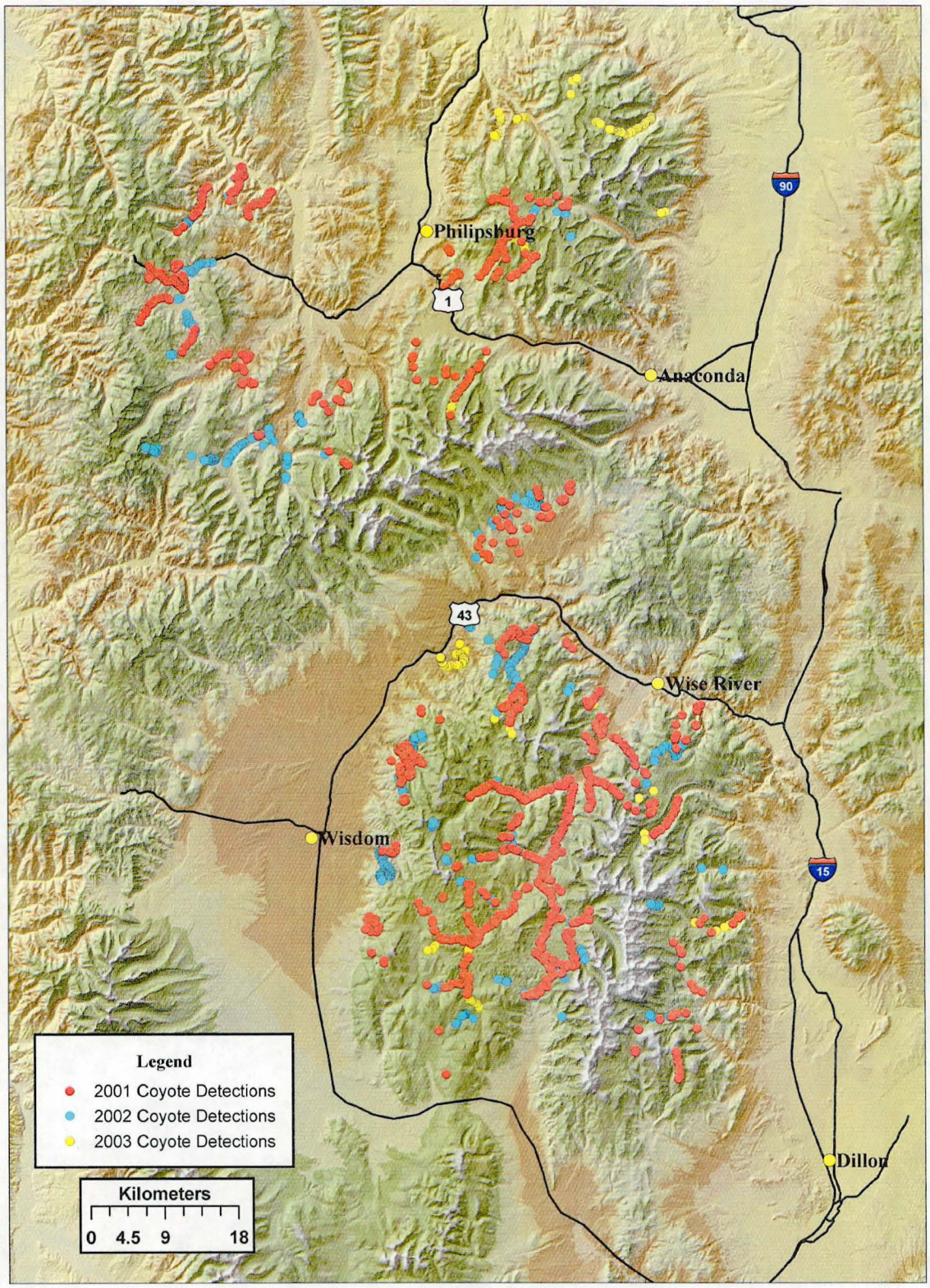

Figure 4: Coyote tracks (n=1075, 630, 256) detected during intensive and extensive surveys in 2001, 2002, and 2003 field seasons, respectively.

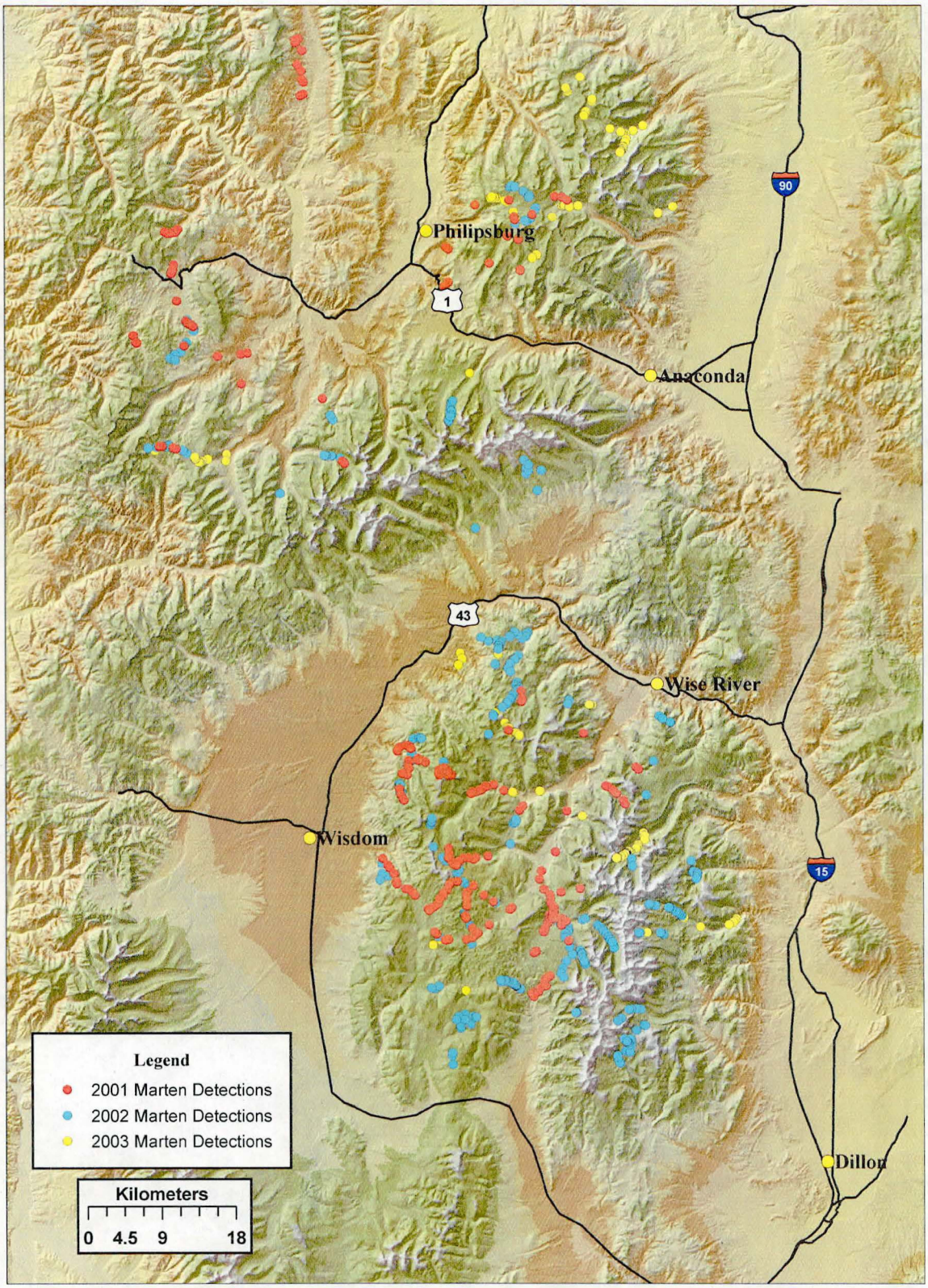

Figure 5: Marten tracks (n=205, 340, 160) detected during intensive and extensive surveys in 2001, 2002, and 2003 field seasons, respectively.

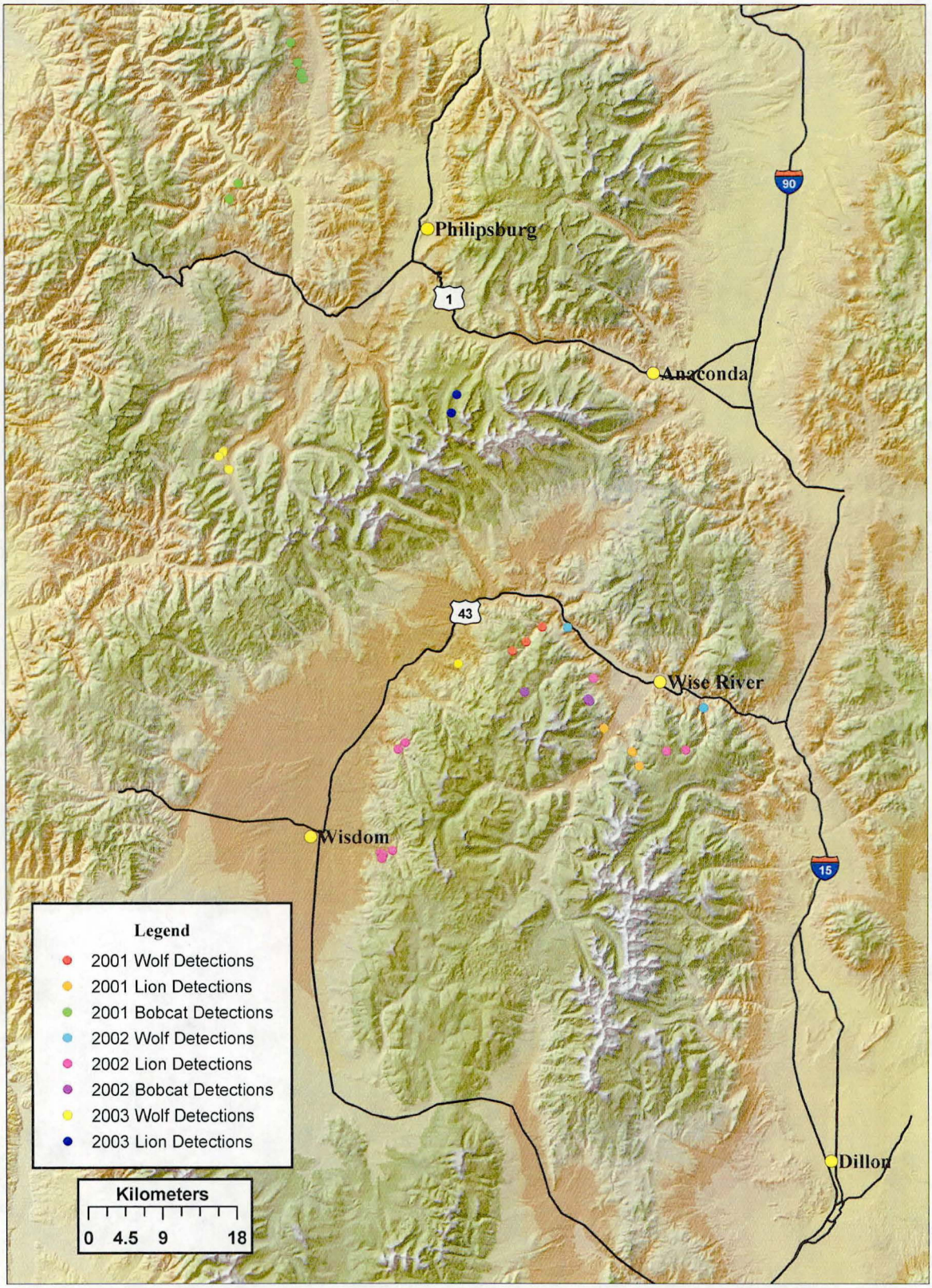

Figure 6: Bobcat (n=10, 2, 1), lion (n=5,13,24), and wolf (n=3,2,10) tracks detected during intensive and extensive surveys in 2001, 2002, and 2003 field seasons, respectively.

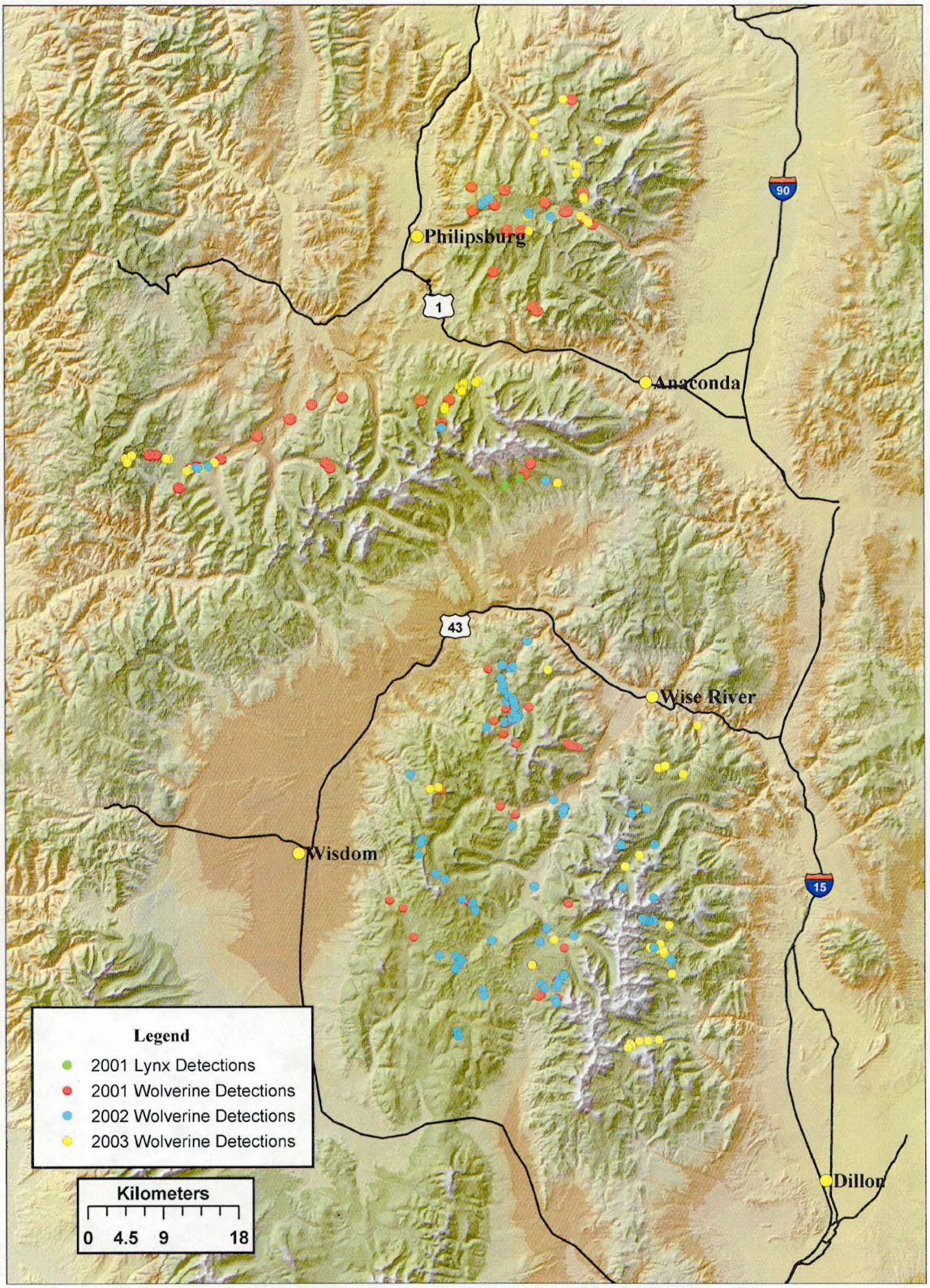

Figure 7: Lynx (n=1, 0, 0) and wolverine (n=36, 115, 96) tracks detected during intensive and extensive surveys in 2001, 2002, and 2003 field seasons, respectively.

presence, therefore inflating our numbers. As a result, in 2003 we tracked our detections separately for surveys and for trap checks. During 2003, 54 of our total of 96 detections were observed during 3,200 km of trap checks, for an average of 59 km per detection. The remaining 42 detections were made during 1,172 km of surveys, for an average effort of 28 km per detection.

Pioneer Mountains Scenic Byway Surveys and Wolverine Backtracks

We completed 20 surveys of the Scenic Byway from 2001 to 2003. Six were completed in 2001, 8 in 2002, and 6 in 2003. Species crossing the Byway during the winter included wolverines (n=15), martens (n=108), coyotes (n=580), snowshoe hares (n=366), squirrels (n=434), moose (n=125), and other ungulates (n=61, Table 1). No lynx, wolf, bobcat, or mountain lion were documented crossing the Byway in any of the 3 years.

We documented 4 wolverine crossings during 6 surveys in 2001, with one additional crossing documented during a non-survey day. Two crossings were located by Moose Park, while the other 3 crossings were concentrated approximately 4km south near Goodenough Park (Figure). During 2002, we documented 4 crossings that were detected on 3 of 8 survey days, as well as 5 additional crossings on non-survey days. Two of these crossings were in close proximity to the 2001 crossings at Goodenough Park, 3 were clumped just south of Pattengail trailhead, 1 was south of Lacy View, and 3 were clumped near the switchbacks at Mono Creek (Figures 8 & 9). During 2003, we documented a single wolverine crossing during 6 surveys. This track was located crossing through the switchbacks at Mono Creek.

In addition to wolverines, we frequently encountered martens (Figures 10 & 11) and coyotes (Figure 12 & 13) during surveys of the Scenic Byway, as well as snowshoe hares (*Lepus americanus,* Figures 14 & 15), red squirrels (*Tamiasciurus hudsonicus,* Figures 16 & 17) and moose (*Alces alces*, Figures 18 & 19). However, there were differences in where various species crossed and how they used the packed snow surface (Table 2). For example, coyotes, which were encountered along the entire length of the road, were the only species to use the road itself as a travel route. Martens, hares, squirrels, and ungulates typically only crossed the road. There were considerable differences among species in terms of preferred vegetation structure and

Table 1. Number of track crossings along the Pioneer Mountain Scenic Byway by species as detected during Byway surveys in 2001 (n=6), 2002 (n=8), and 2003 (n=6).

Species	*2001*	*2002*	*2003*	*Figure #*
Wolverine	5	9	1	8,9
Marten	34	25	49	10,11
Coyote	188	134	258	12,13
Hare	174	147	145	14,15
Squirrel	89	102	243	16,17
Moose	54	58	13	18,19
Elk	30	9	22	18,19

Table 2. Manner in which species used the road surface of the Pioneer Mountains Scenic Byway during the winter. Based on Scenic Byway winter surveys in 2001 (n=6), 2002 (n=8), and 2003(n=6).

Use of Packed Snow Track	Coyote	Marten	Wolverine	Moose	Hare	Squirrel
2001 Season:						
Tracks On/Off Packed Snow	63%	3%	20%	6%	5%	0
Tracks On Packed Snow>100m	14%	0	0	0	0	0
Tracks on Packed Snow <100m	7%	0	0	1%	0	0
Tracks Crossing Packed Snow	16%	97%	80%	93%	95%	100%
Total Detections	**188**	**34**	**5**	**54**	**174**	**89**
2002 Season:						
Tracks On/Off Packed Snow	41%	8%	0	10%	0	0
Tracks On Packed Snow>100m	12%	0	0	0	0	0
Tracks on Packed Snow <100m	17%	0	0	7%	1%	0
Tracks Crossing Packed Snow	30%	92%	100%	83%	99%	100%
Total Detections	**134**	**25**	**6**	**58**	**147**	**101**
2003 Season:						
Tracks On/Off Packed Snow	35%	6%			5%	1%
Tracks On Packed Snow>100m	12%					
Tracks on Packed Snow <100m	16%			8%	3%	
Tracks Crossing Packed Snow	35%	94%	100%	92%	92%	99%
Total Detections	**258**	**49**	**1**	**13**	**145**	**243**

Figure 8: Wolverine crossings (n=5, 9, 1) detected along the northern section of the Pioneer Mountain Scenic Byway during Byway surveys in 2001, 2002, and 2003, respectively.

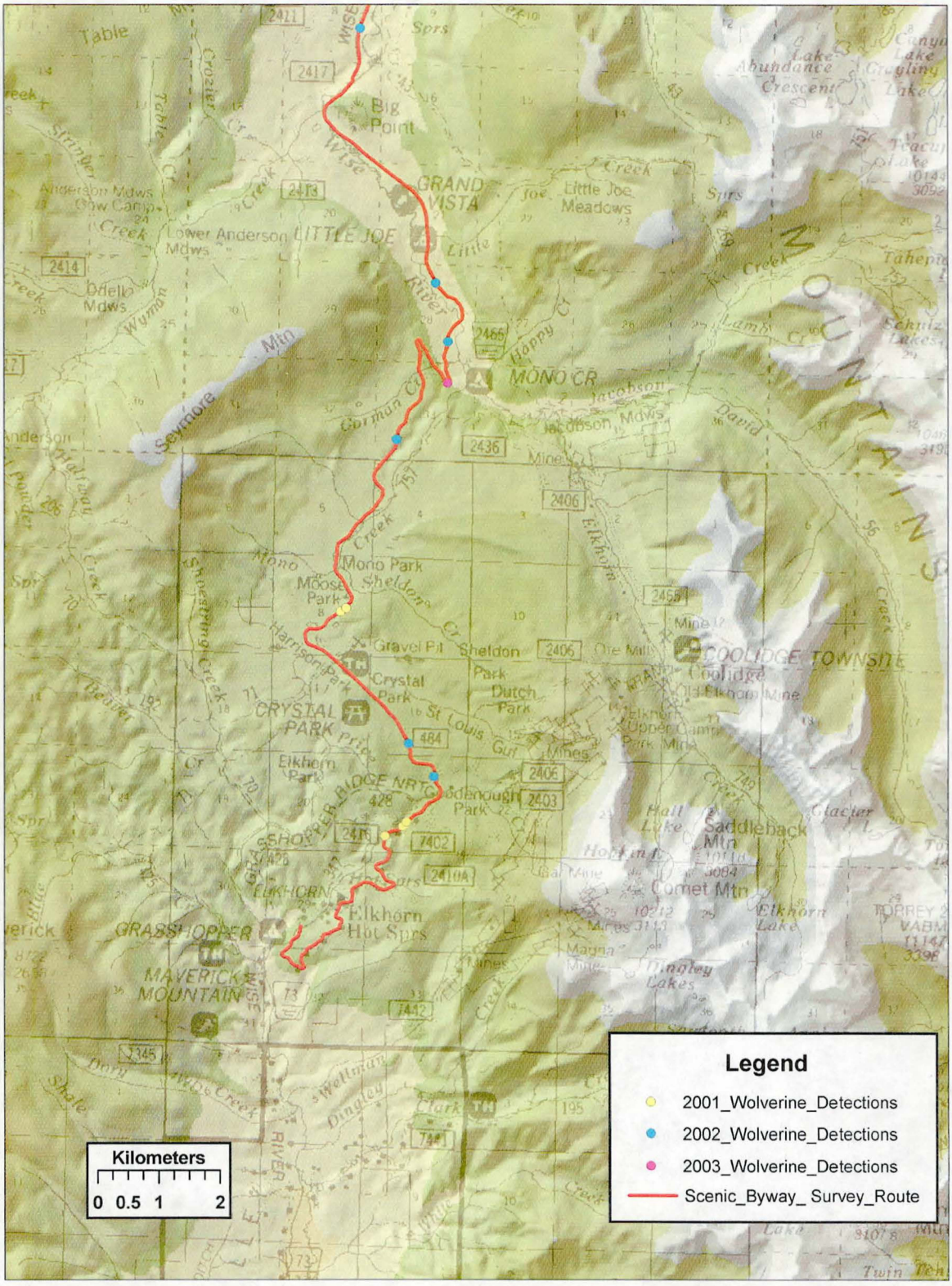

Figure 9. Wolverine crossings (n=5, 9, 1) detected along the southern section of the Pioneer Mountain Scenic Byway during Byway surveys in 2001, 2002, and 2003, respectively.

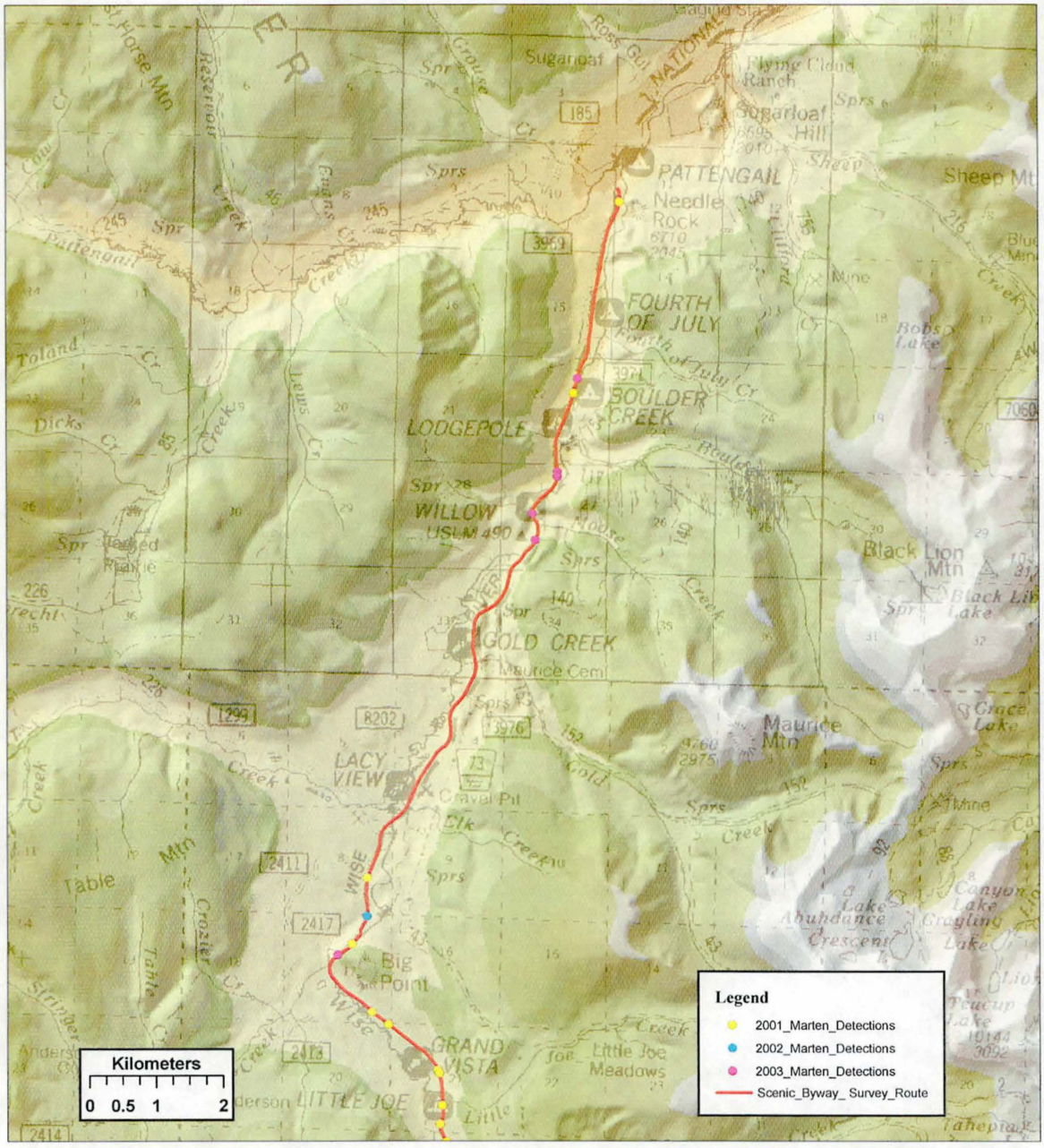

Figure 10. Marten crossings (n=34, 25, 49) detected along the northern section of the Pioneer Mountain Scenic Byway during Byway surveys in 2001, 2002, and 2003, respectively.

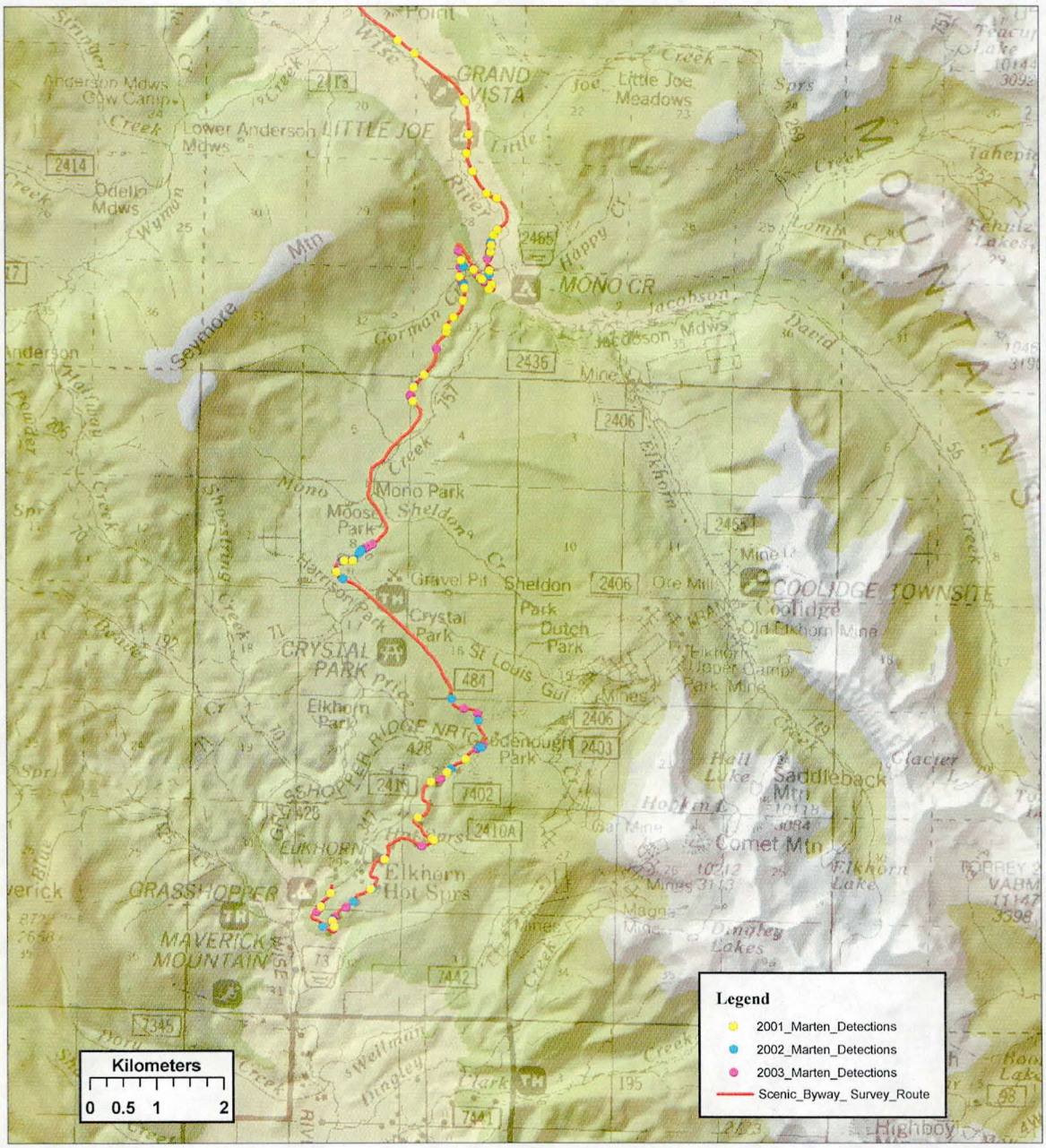

Figure 11. Marten crossings (n=34, 25, 49) detected along the southern section of the Pioneer Mountain Scenic Byway during Byway surveys in 2001, 2002, and 2003, respectively.

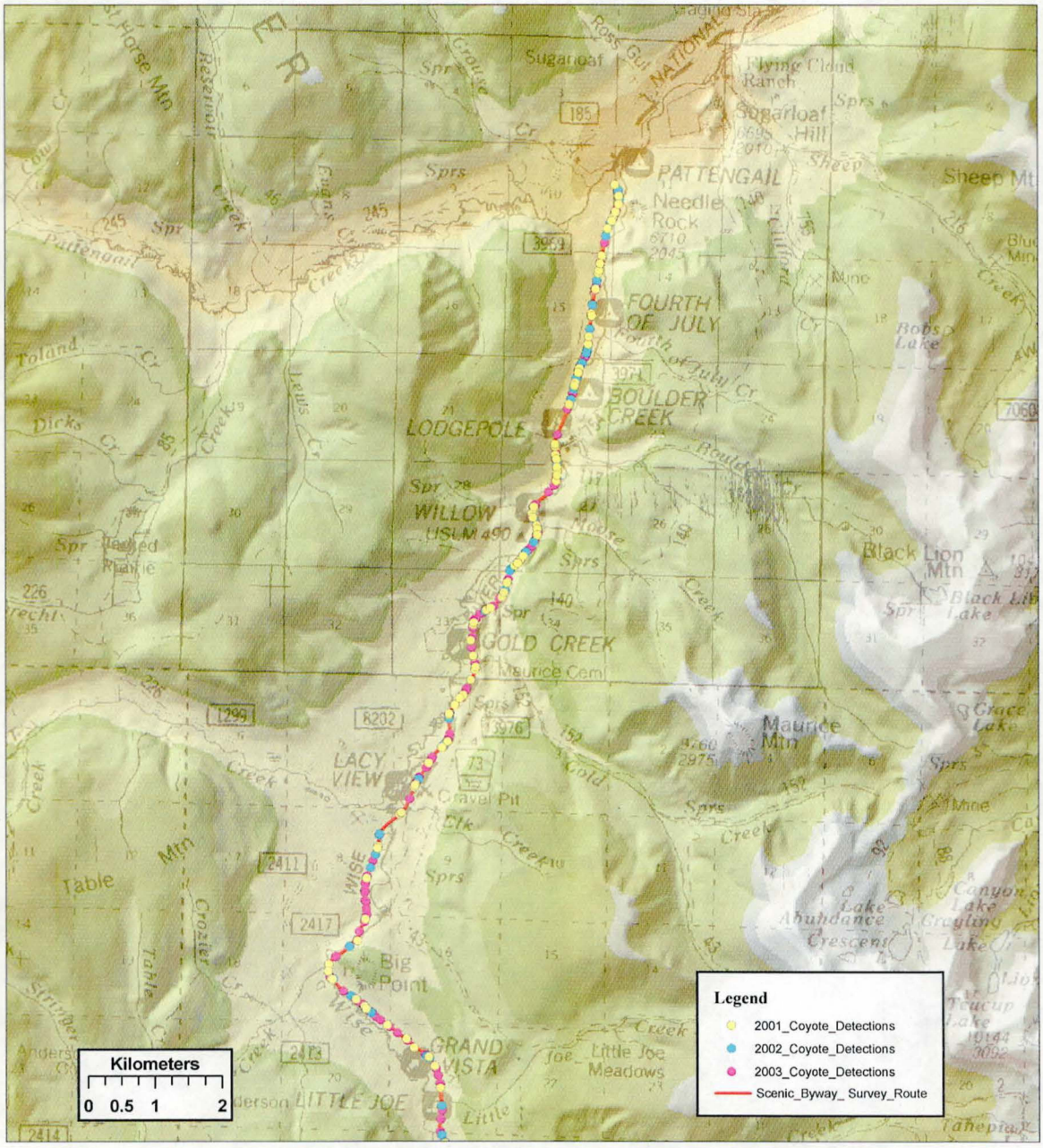

Figure 12: Coyote crossings (n=188, 134, 258) detected along the northern section of the Pioneer Mountain Scenic Byway during Byway surveys in 2001, 2002, and 2003, respectively.

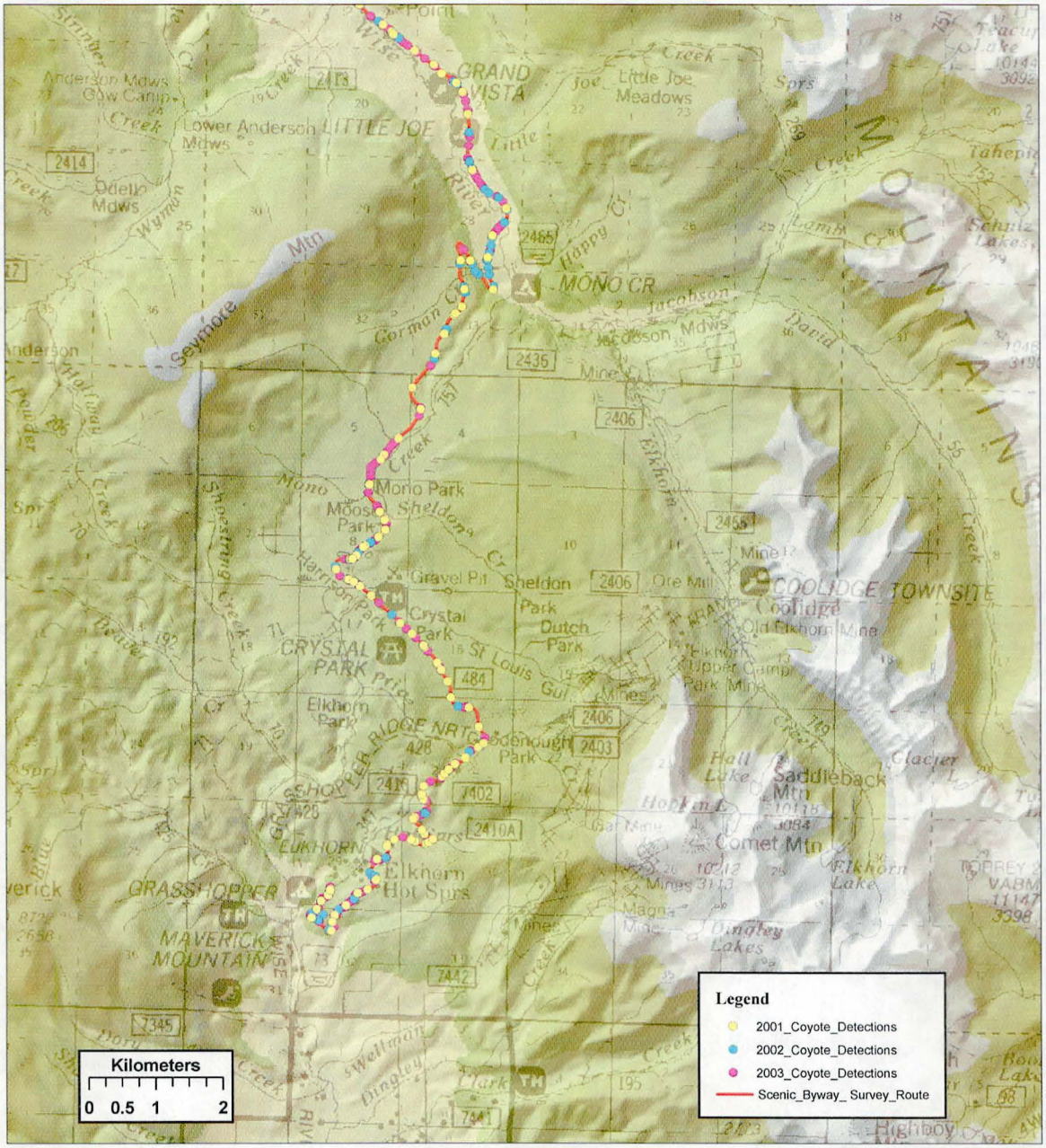

Figure 13. Coyote crossings (n=188, 134, 258) detected along the southern section of the Pioneer Mountain Scenic Byway during Byway surveys in 2001, 2002, and 2003, respectively.

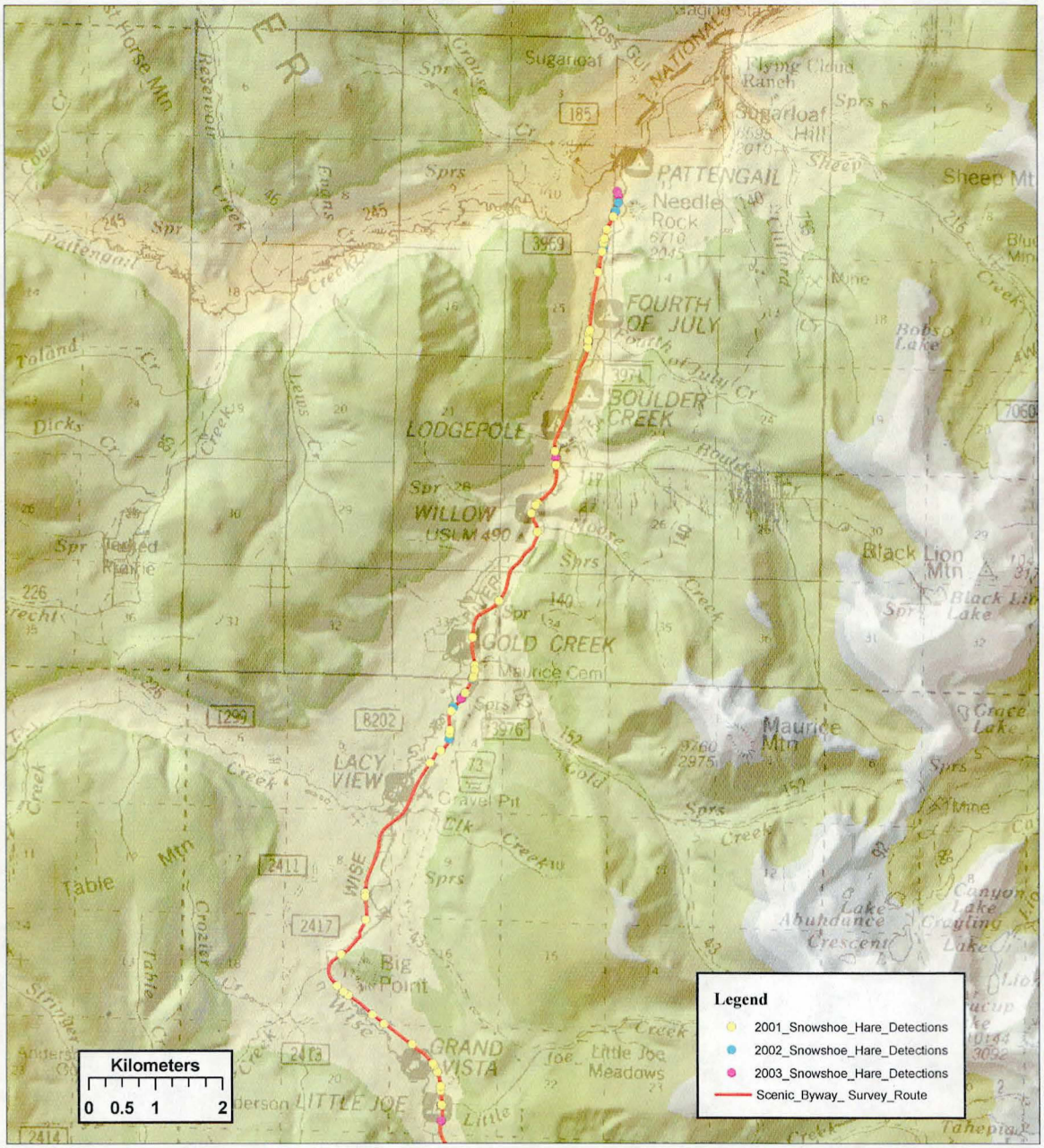

Figure 14. Snowshoe hare crossings (n=174, 147, 145) detected along the northern section of the Pioneer Mountain Scenic Byway during Byway surveys in 2001, 2002, and 2003, respectively.

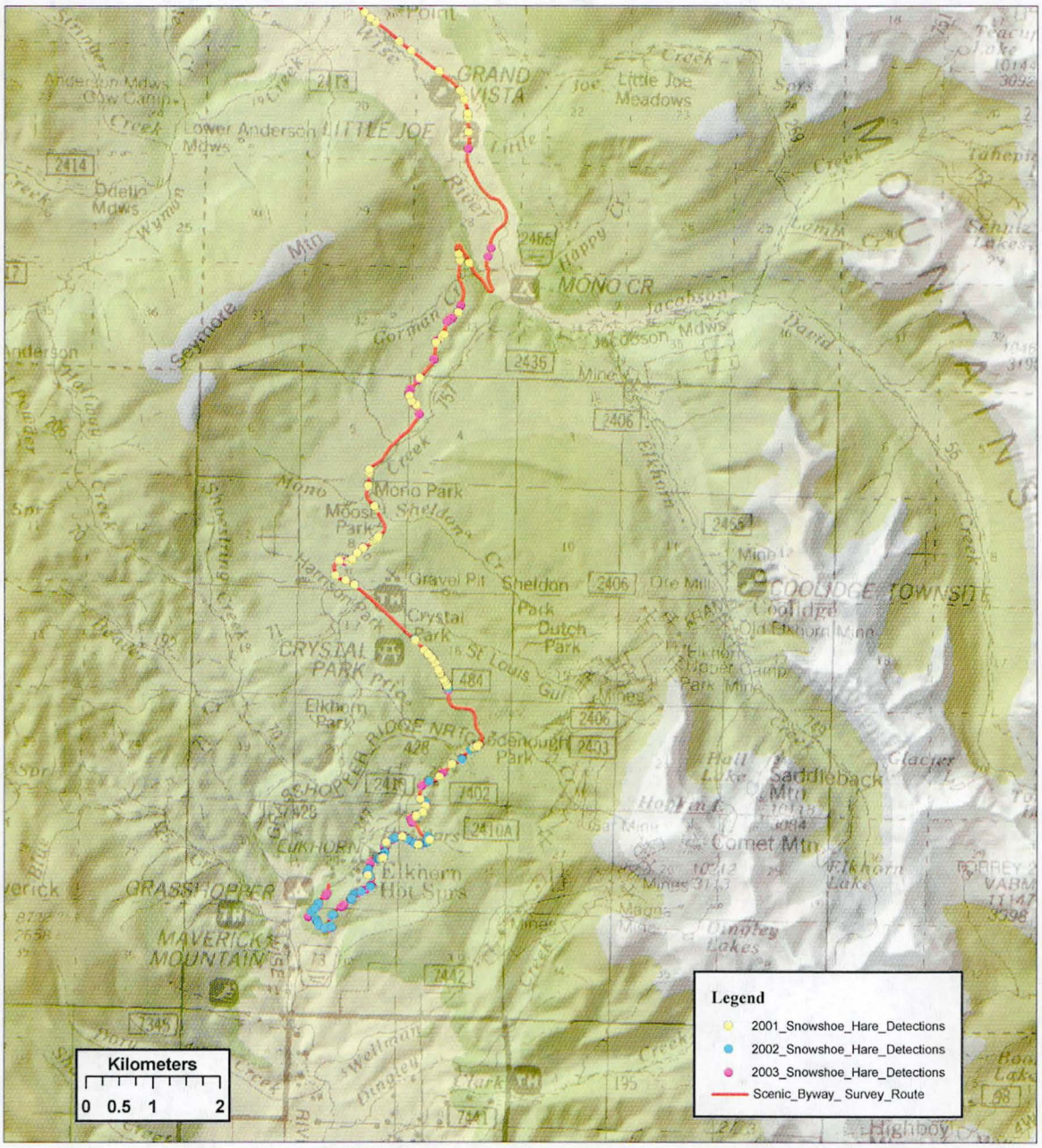

Figure 15. Snowshoe hare crossings (n=174, 147, 145) detected along the southern section of the Pioneer Mountain Scenic Byway during Byway surveys in 2001, 2002, and 2003, respectively.

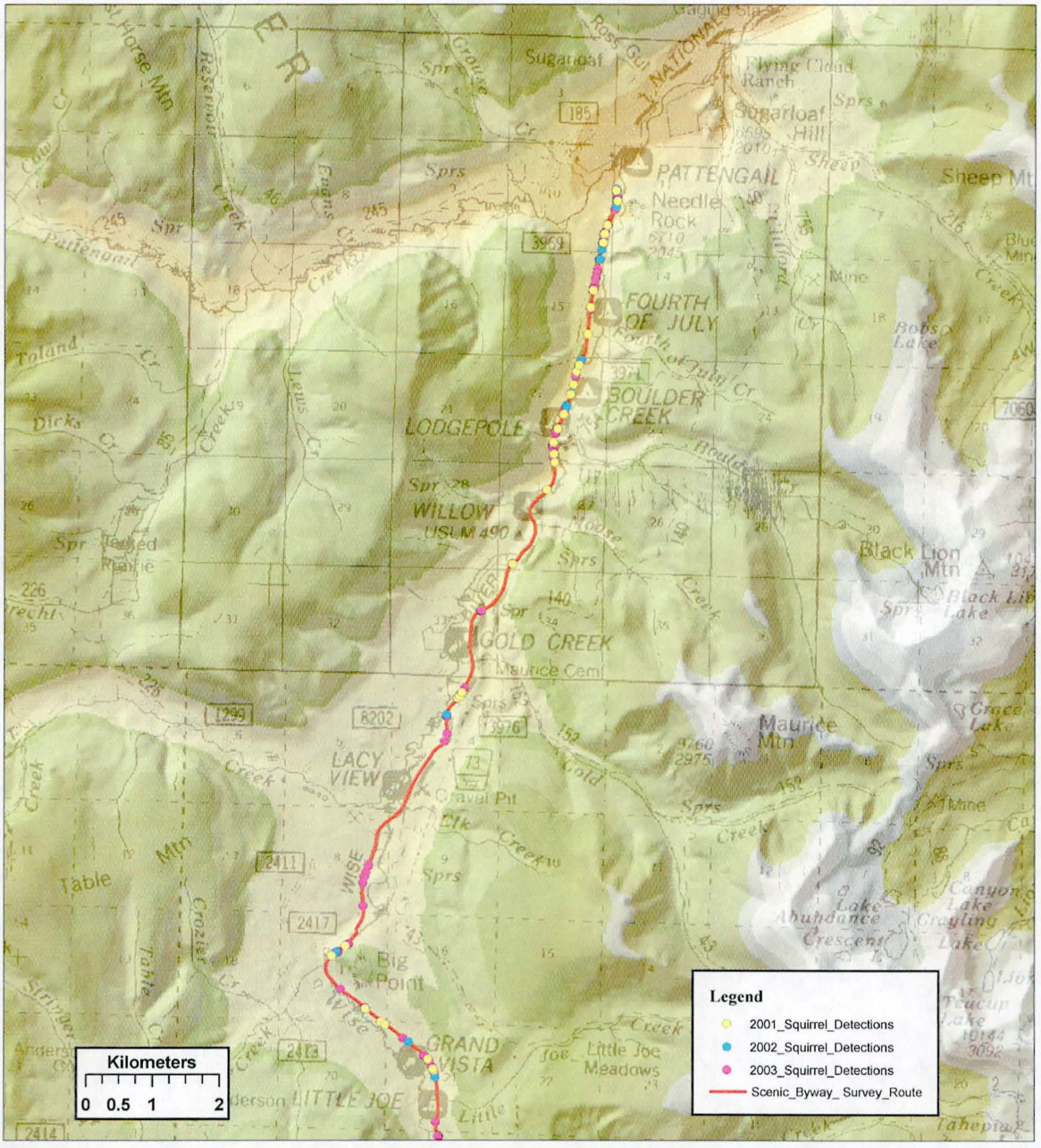

Figure 16. Red squirrel crossings (n=89, 102, 283) detected along the northern section of the Pioneer Mountain Scenic Byway during Byway surveys in 2001, 2002, and 2003, respectively.

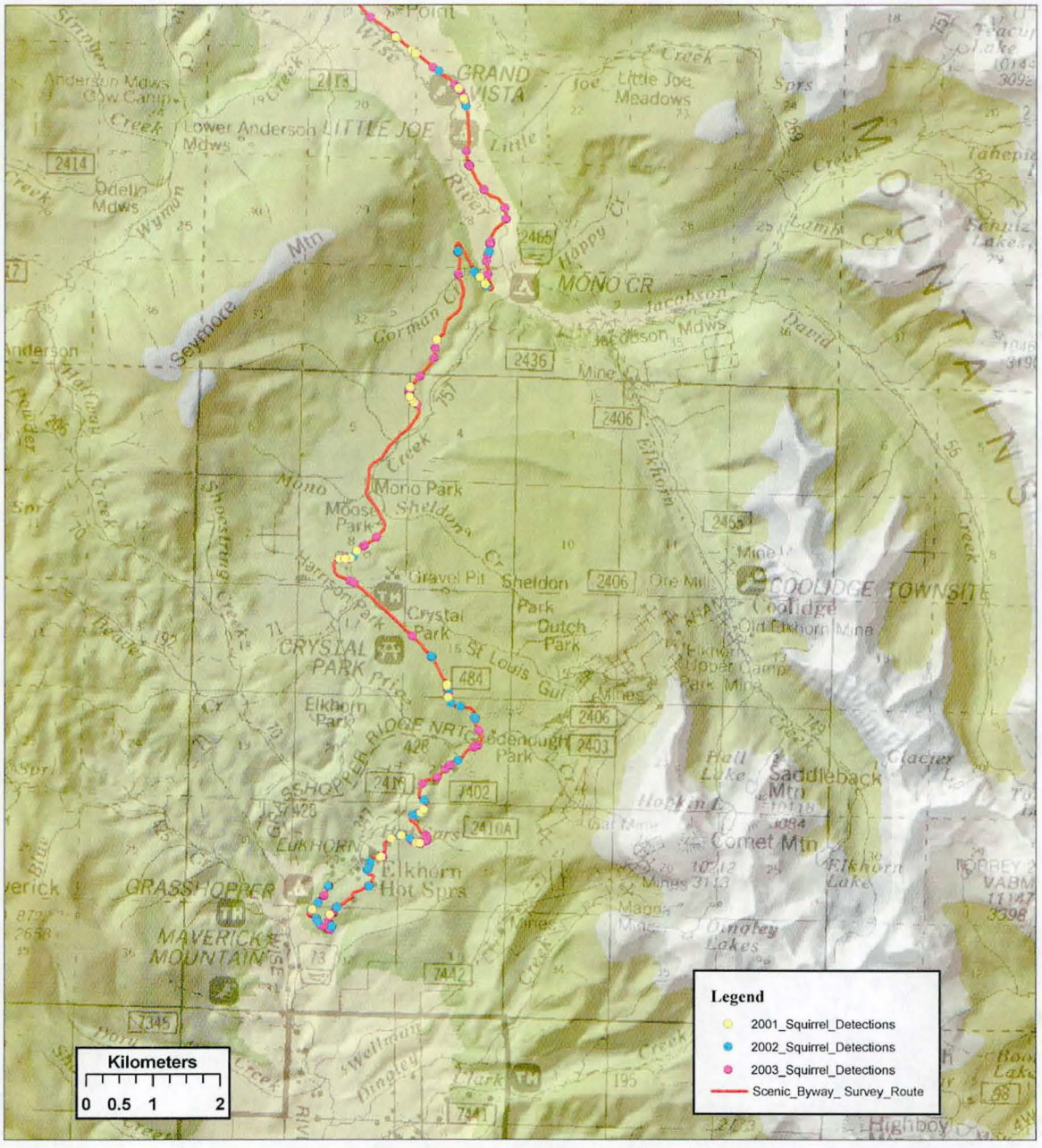

Figure 17. Red squirrel crossings (n=89, 102, 283) detected along the southern section of the Pioneer Mountain Scenic Byway during Byway surveys in 2001, 2002, and 2003, respectively.

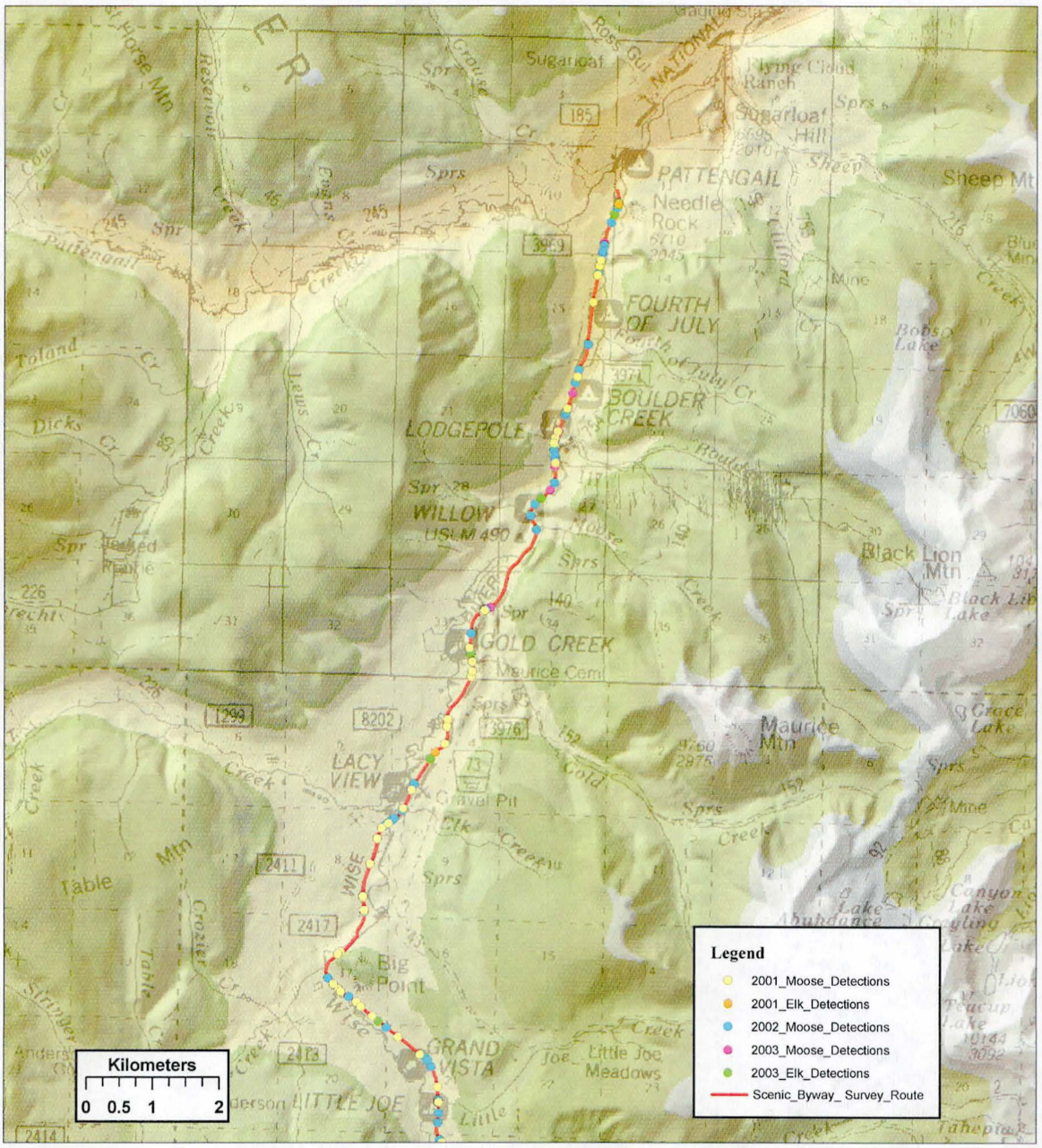

Figure 18. Moose (n=54, 58, 13) and Elk (n=4, 0, 11) crossings detected along the northern section of the Pioneer Mountain Scenic Byway during Byway surveys in 2001, 2002, and 2003, respectively.

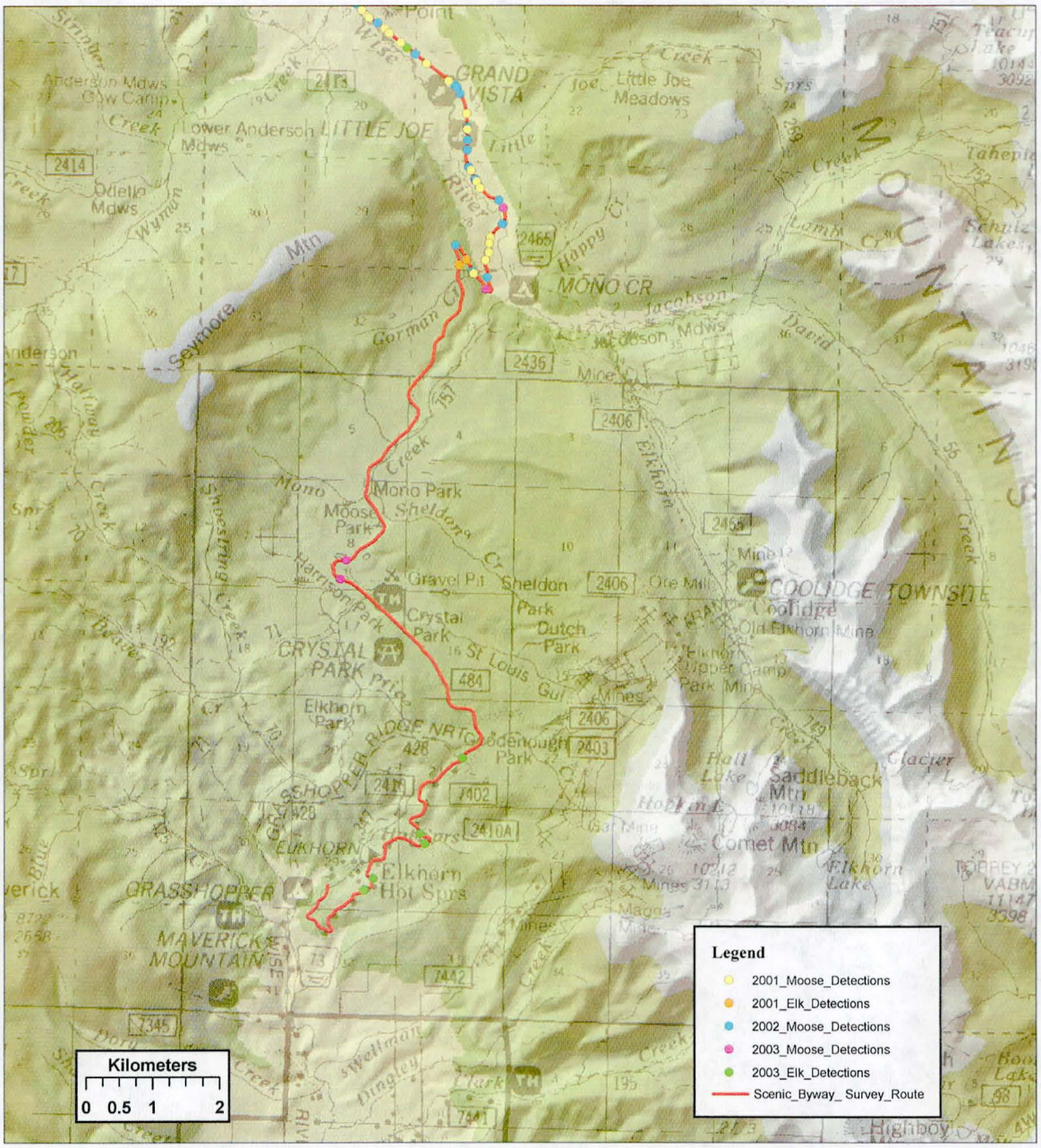

Figure 19. Moose (n=54, 58, 13) and Elk (n=4, 0, 11) crossings detected along the southern section of the Pioneer Mountain Scenic Byway during Byway surveys in 2001, 2002, and 2003, respectively.

composition at crossing points. Coyotes selected for forested habitats while selecting against open grassland habitats (Appendix A, Table 3). Martens selected for mixed Subalpine fir and mixed lodgepole/doug-fir habitats, while selecting against shrublands, grasslands, aspen, and willow habitats (Appendix A, Table 4). Moose selected for shrubland, willow, and aspen habitats while selecting against grasslands (Appendix A, Table 7). Hares selected for multistory mixed-subalpine fir forests found at higher elevations, while selecting against other types of forest, shrublands, and grasslands (Appendix A, Table 5). Lastly, squirrels selected for mixed-type forests of subalpine fir, doug-fir, and lodgepole pine, while selecting against grasslands, shrublands, mixed-spruce forests, and willow habitats (Appendix A, Table 6).

Snow trails of wolverines approaching the Polaris Bypass suggest this road was not a barrier to movement during the winter when the road is a fairly high-traffic snowmobile road (Figures 20-24). In 6 of 7 backtracks the wolverine directly crossed the road with no sign that they "bounced" against this putative barrier. We documented only a single track where the wolverine failed to cross the road on its first approach, but did cross as the animal approached the road a second time (Figure 20). Additionally, certain backtrack routes suggest wolverines appeared to use forested areas and avoid clearings where possible (Figures 22-24).

Project Trapping

During the summer of 2001, we built 15 live traps built from logs in selected areas of the Pioneers, Anaconda-Pintlers, and Flint Creek ranges. In 2002, we trapped a total of 350 trap nights, during which we had 9 captures of 5 individual wolverines for an average of 70 nights per new individual. One adult male wolverine, 2 yearling males, and 1 yearling female were captured in the Pioneer range, whereas 1 adult male was captured in the Anaconda-Pintler range. We measured, weighed, and implanted each animal with a VHF transmitter before release; blood, tissue, and hair were also collected for DNA analysis.

We built 5 additional traps during 2002 to improve trap coverage of the study area. We had 12 captures of 7 individuals (5 males, 2 females) from January 15 – April 10th during 855 trap nights of effort. Four of these animals were new captures, resulting in an effort of 214 trap nights per new individual. The new wolverines consisted of a pregnant adult female, a yearling female, and an adult male in the Pioneer Mountains, as well as an adult male in the Flint Creek Range. Previous wolverine studies in the conterminous US captured from 3 to 6 wolverines per year (Hornocker and Hash 1981, Copeland 1996), and our project is in line with these results.

Due to the long life of the implants, there has not yet been a need to recapture animals for re-implantation. However, during 2003 we did target certain animals for recapture to document condition and to instrument them with GPS collars. Trapping effort in 2002 was much lower than in 2003. The average effort to capture a new wolverine was 70 trap nights in 2002, versus 214 nights in 2003. The animals captured in 2002 were the result of our placing the traps in high-use areas identified the previous year. However, in 2003, we believe the reduction in animals on the study area from recreational trapping reduced our ability to capture wolverine.

Wolverine Mortality

We documented 6 wolverine mortalities during the study. A large predator killed M3, a male that we captured as a subadult in February 2002, during September 2003. The cause of death was massive trauma to the top the skull as a result of a bite. In addition, both hindquarters of the carcass had been consumed. Evidence at the site, such as the halo of plucked hair, is typical of mountain lion kills, however this evidence and the necropsy were inconclusive. Predation of wolverine by large carnivores, such as mountain lions and bears, appears to be infrequent but has been documented by previous studies in the lower 48 states (Hornocker and Hash 1981, Bob Inman, WCS, Personal Communication).

The 5 remaining wolverine mortalities were due to recreational trapping. The large resident male (M2) that was captured by our project in February 2002 was harvested by a Dillon trapper in late January 2003 in the southeast Pioneers. The pregnant female (F6) we captured on Februay 8th, 2003 was harvested by a local trapper a week later in the northeast Pioneers. In addition to these instrumented study animals, 3 additional wolverines were harvested by local trappers in the study area during the 2002-2003 season according to state trapping records. Two adult males were reportedly harvested out of the Pioneers, although project evidence regarding trapper activity in the proposed area and DNA genotype analysis suggest the actual location was the Anaconda-Pintler range, and one animal was checked in from the Trail Creek area in the southern Anaconda-Pintler range.

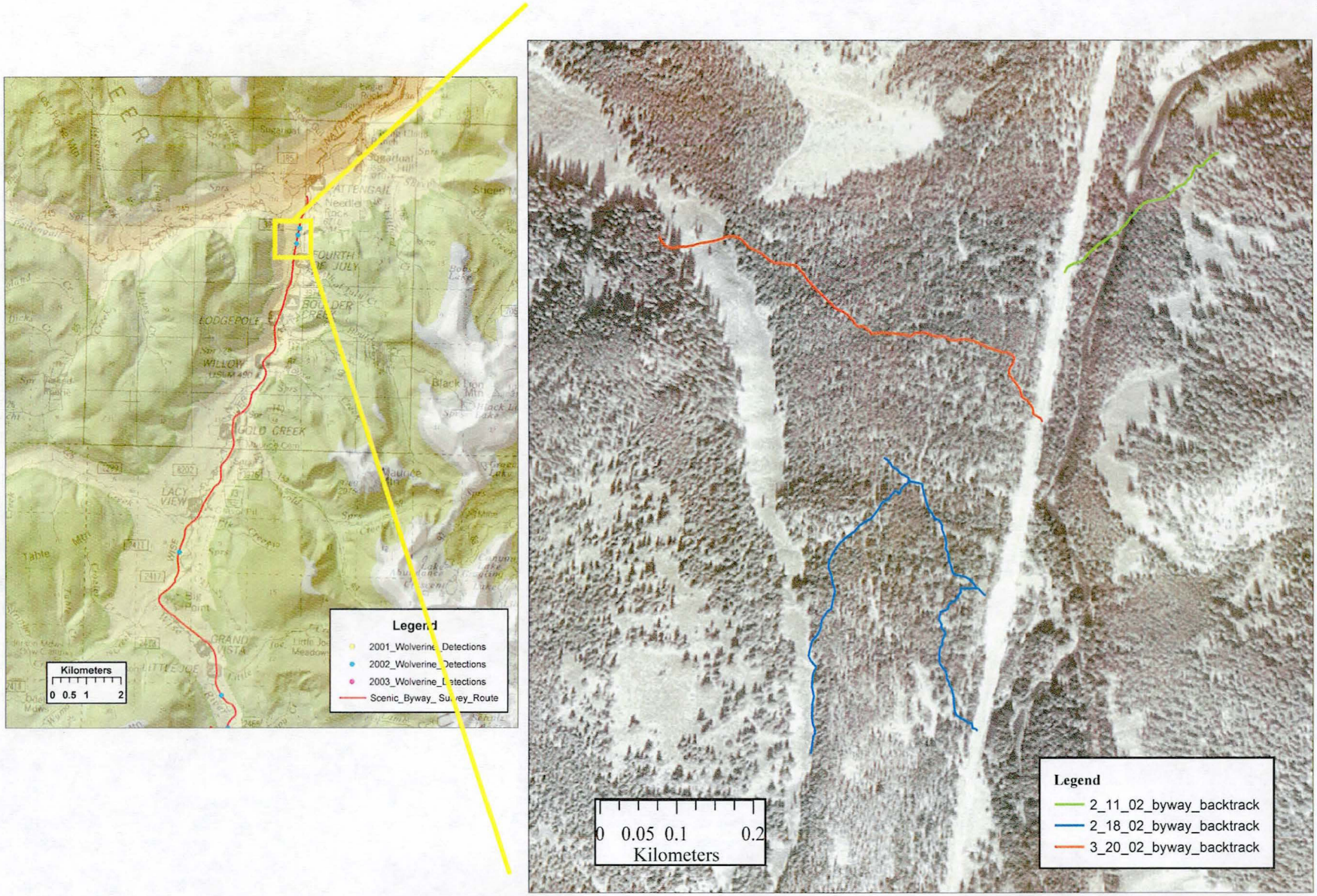

Figure 20. Three backtracks of wolverine crossing the Byway during winter. This road is a major snowmobile trail during this time of year.

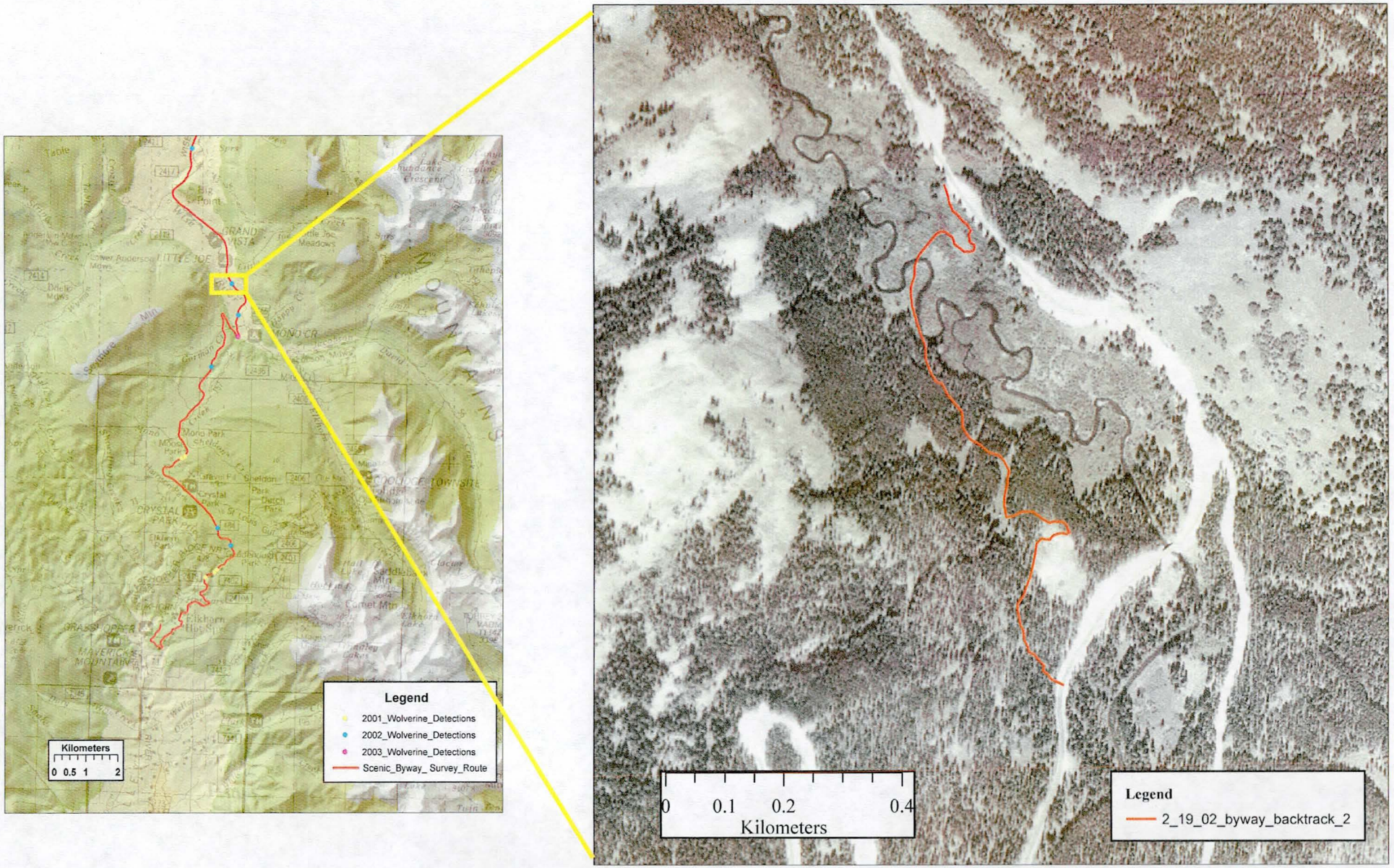

Figure 21. Fourth backtrack of wolverine crossing the Byway during winter; this road is a major snowmobile trail during this time of year.

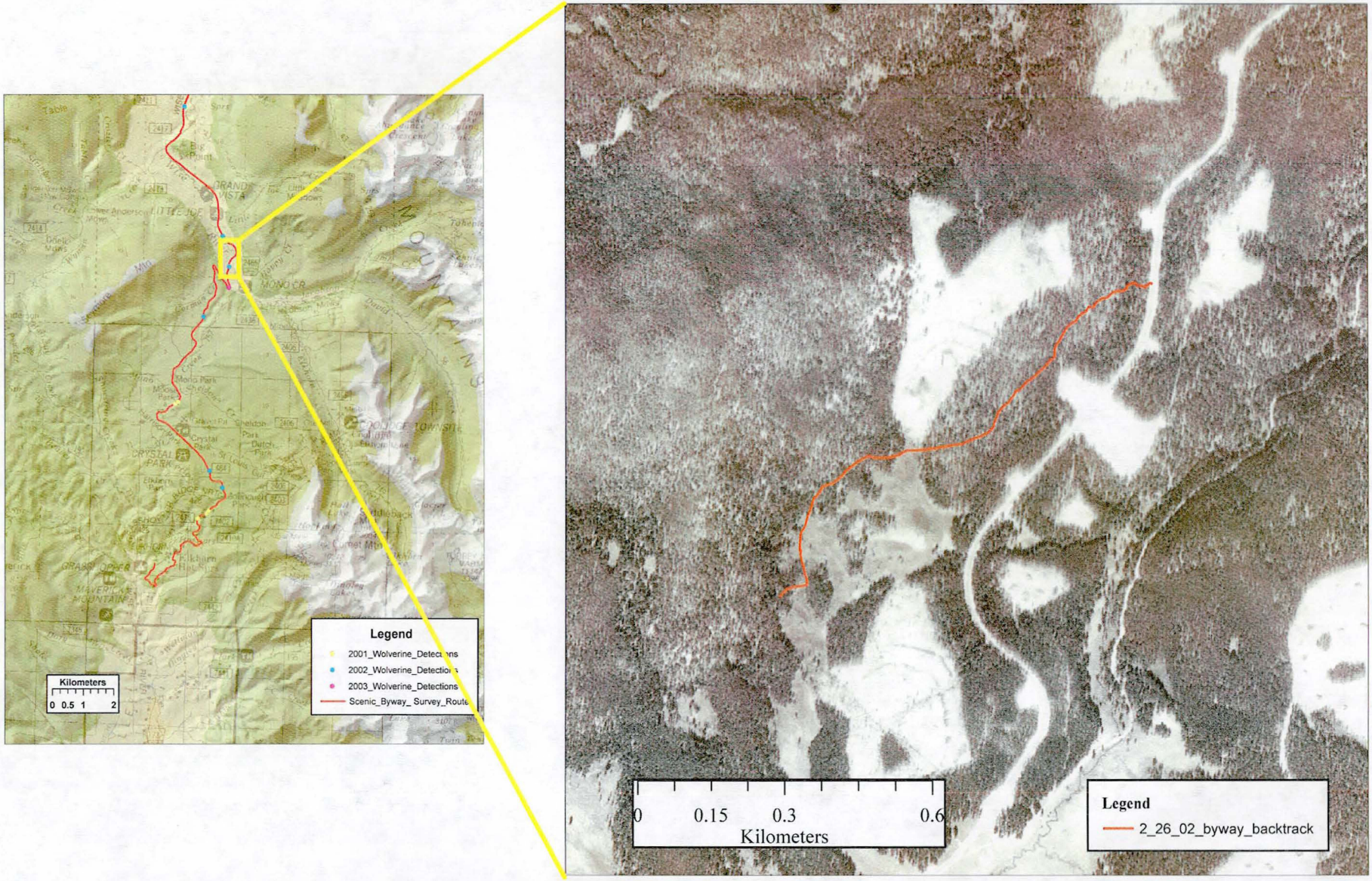

Figure 22. Fifth backtrack of wolverine crossing the Byway during winter; this road is a major snowmobile trail during this time of year.

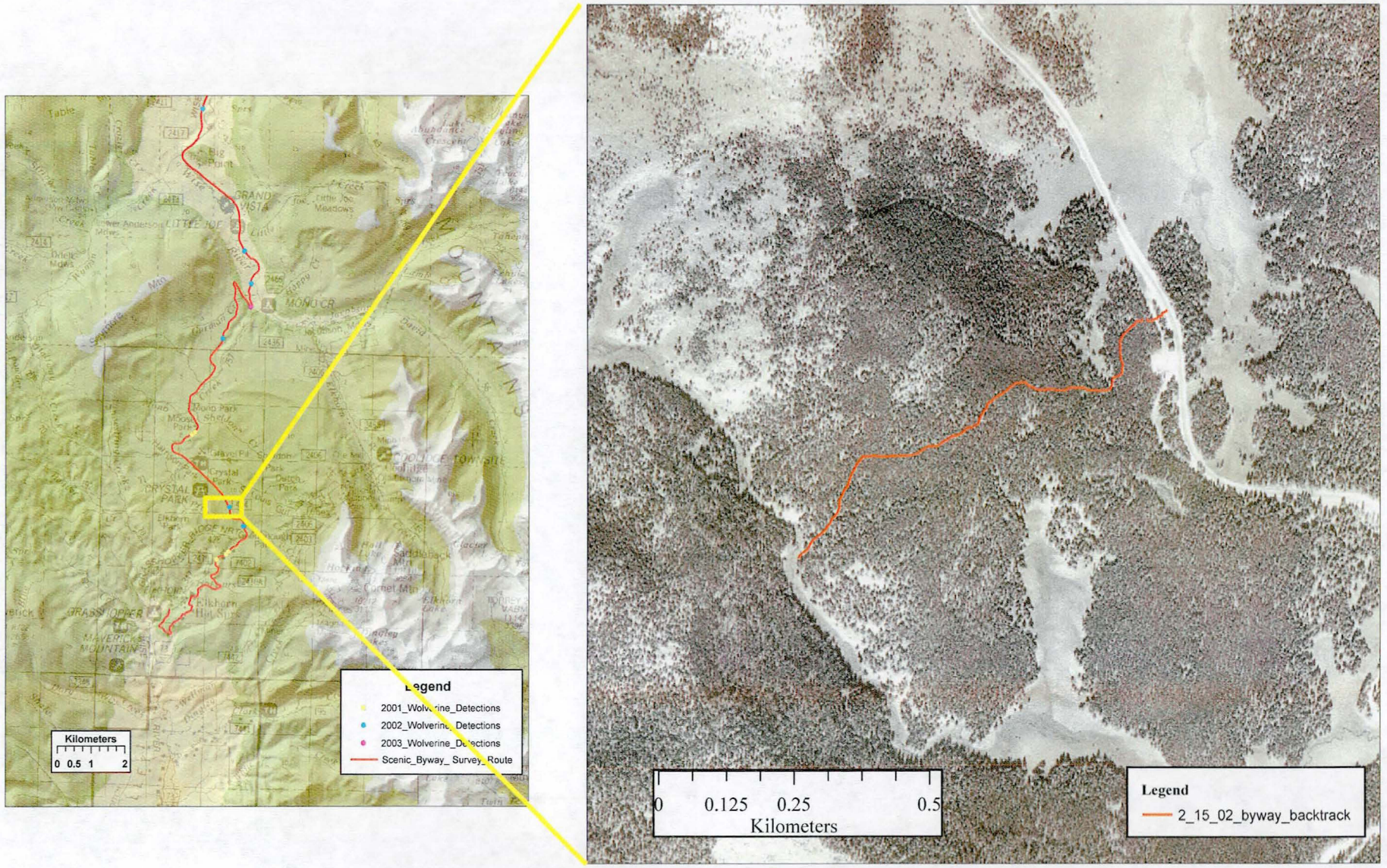

Figure 23. Sixth backtrack of wolverine crossing the Byway during winter; this road is a major snowmobile trail during this time of year.

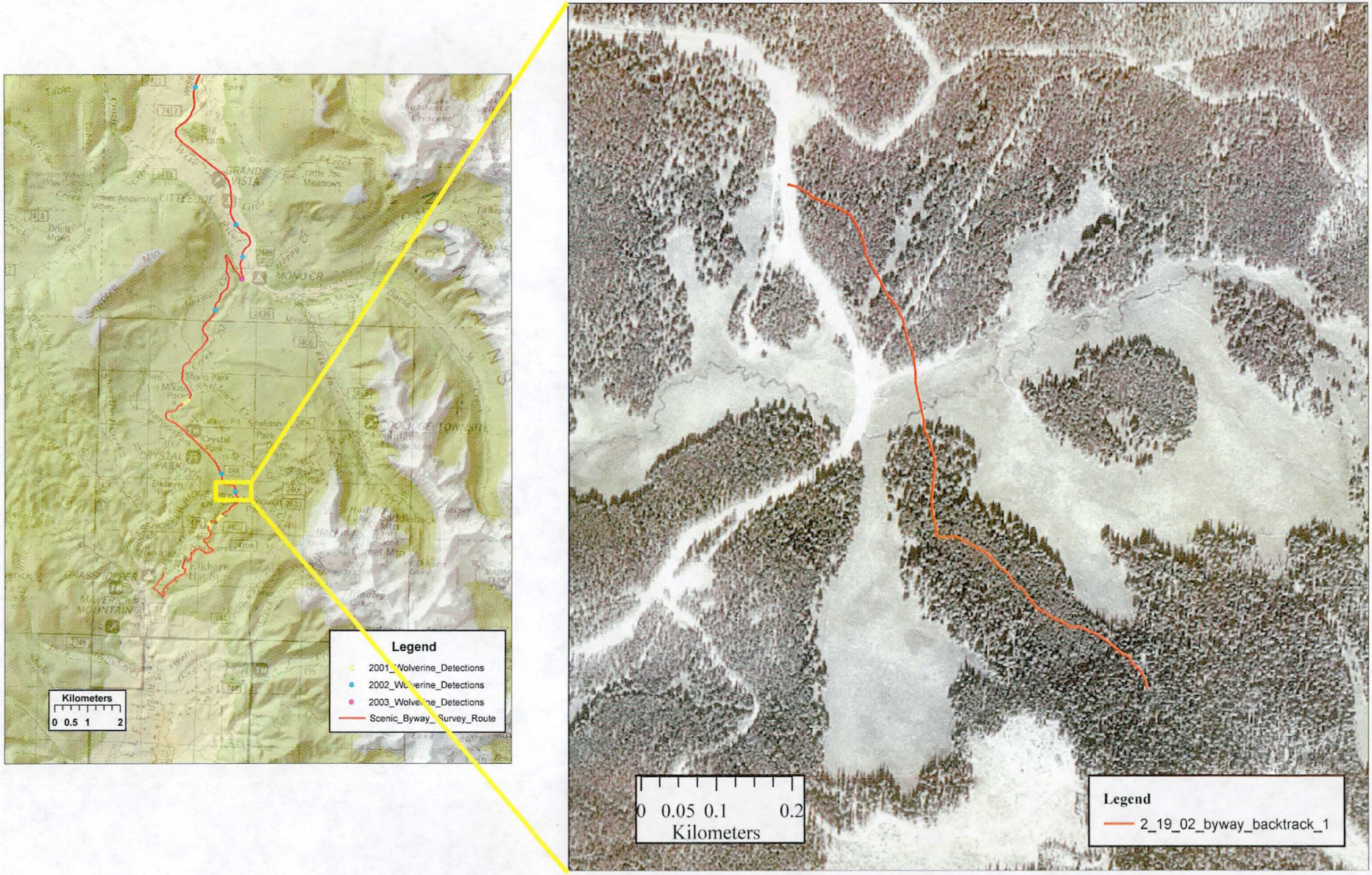

Figure 24. Seventh backtrack of wolverine crossing the Byway during winter; this road is a major snowmobile trail during this time of year.

Table 8: Summary of animal age-class, year of capture, number of aerial telemetry relocations, duration of monitoring, homerange summaries, and fate for all instrumented wolverines in the Pioneers, Anaconca-Pintler, and Flint Creek mountain ranges as of July 16th, 2003.

ID	Sex	Age Class at Capture	First Captured	Number of relocations	Duration followed (mo.)	Kernel Homerange (km2)	Fate
M1	Male	Sub-adult	2002	35	16	277	Still transmitting
M2	Male	Adult	2002	30	11	1,445	Dead -Harvested 2/03
M3	Male	Sub-adult	2002	22	15	151	Dead-Predation 7/02
F4	Female	Sub-adult	2002	35	11	178	Still transmitting
M5	Male	Adult	2002	34	15	1,041	Still transmitting
F6	Female	Adult	2003	1	<1	N/A	Dead -Harvested 2/03
M7	Male	Adult	2003	6	5	N/A	Still transmitting
F8	Female	Sub-adult	2003	6	5	N/A	Still transmitting
M9	Male	Adult	2003	1	4	N/A	Lost - Transmitter issue

Aerial Telemetry and Home Ranges

The average home range for two adult males was 1243 km^2 and 290 km^2 for two juvenile males (Table 8). The only female, F4, which had enough relocations for home range analysis, had a range of 178 km^2. Mean summer use per individual male wolverine was: M1 mean=2225, range=1810-1459, SD=159; M2 mean=2407, range=2012-3023, SD=196; M3 mean=2265, range=2064-2569, SD=153; and M5 mean=2364, range 2034-2816, SD=206. Mean summer elevation use for all male wolverines was 2315 meters (n=4, SD=84). Mean winter elevation use per individual male wolverine was: M1 mean=2291, range=2094-2516, SD=138; M2 mean=2374, range=2116-2531, SD=141; M3 mean=2229, range= 2207-2243, SD=19; and M5 mean=2321, range=2077-2603, SD=165. Mean winter elevation use for all male wolverine was 2304 meters (n=4, SD=60). Mean winter elevation use per individual female wolverine was: F4 mean=2637, range=2312-2918, SD=177; F8 mean=2553, range=2489-2599, SD=57. Mean winter use for all female wolverine was 2595 meters (SD=59). Mean summer elevation use by each individual female wolverine was: F4 mean=2708, range=2305-3026, SD=197; F8 mean=2576 , range=2353-2809, SD= 197. Mean summer elevation use for all female wolverine was 2642 (n=2, SD=93). Wolverines used elevations similarly seasonally within sex-class, but females generally used slightly higher elevations than males.

Denning and Winter Recreation

During the three-year study period, no radio-instrumented females denned and produced kits. Both F4, the subadult female captured in 2002, and F8, the subadult captured in 2003, were estimated to be 1-2 years old at the time of initial capture. Investigation of reproductive organs showed that neither female had yet to produce a litter. Since the time to first reproduction for female wolverine can be as late as 3.4 years of age (Persson 2003), it is not surprising that neither female localized and denned during either winter.

The third female captured during our project, F6, was determined to be pregnant by a licensed veterinarian at the time of our initial capture. Tooth wear and body size suggested this female was greater than 4 years old, and investigation of reproductive organs suggested she had previously reproduced and nursed kits. Unfortunately, F6 was captured and killed by a recreational trapper in February 2003, one week after our initial processing. This time period

was inadequate for us to determine her movement patterns to address denning issues, and based on the date and her stage of pregnancy during our initial processing, she was most likely still pregnant and had not given birth at the time of her death.

Discussion

Lynx Ecology

The most surprising and important result relative to highway planning is the absence of lynx in the Pioneer Mountains and adjacent ranges. The impetus for this research project was based on the belief by the plaintiff, as well as local state and federal biologists, that a lynx population existed within the study area. Discussions with local trappers and biologists indicate that lynx were present in the Pioneer Mountains prior to the late 1990's, and had been detected during winter track surveys as recently as 2000 (Forkan 2000). This fact is substantiated by the number of trapped lynx from this area in the 1970s. However, we only documented 1 lynx in 3 mountain ranges over the course of 3 successive field seasons. This provides strong evidence that lynx were either absent or at very low densities during our study. The survey effort we conducted was extremely rigorous and has proven to be effective at detecting lynx at low densities, such as in northwestern Wyoming. We also used these same survey methods in the Seeley-Swan valley, the Purcell Mountains, and the Garnet Mountains of Montana.

The reasons for the decline of lynx in the Pioneer Mountains and adjacent ranges are unclear. Although lynx undergo cyclical population dynamics in Canada (Mowat et al. 2000), the variability in lynx populations in the contiguous United States is not fully understood. McKelvey et al. (2000) found that increases in lynx populations in the contiguous United States lagged Canadian populations by 2-4 years. Thus, lynx populations in Montana are expected to increase about 3 years after the peaks in Canadian populations. Although surveys were conducted during a putative "increase" period, we documented no influx of lynx on the project area.

While increases in lynx populations can be attributed to either immigration or improved local reproduction, there are many possible reasons for declines that include disease, low prey densities, changes in habitat, predation, or human-caused mortality. The habitat types that previously supported lynx are still present in the study area and have not changed significantly during the last decade. Local trappers indicated they noticed a sharp decline in hare numbers

during the late 1990's, but there is no empirical data to test this hypothesis. Project surveys have documented that prey species such as snowshoe hares and squirrels are currently present; however, we do not know if prey occur at the densities necessary to support a lynx population.

In conclusion, we could not address how road improvements may have impacted lynx populations because the species was all but absent from the study area. Given the limited evidence that lynx populations in Montana fluctuate with flows from Canada (McKelvey et al. 2000, Schwartz et al. 2002) the Pioneer Mountains and adjacent ranges may or may not repopulate. Thus, the "empty" habitats currently in these ranges may become important in the dynamics of lynx metapopulations if these areas are repopulated.

Wolverine Distribution

Wolverines were present in all three mountain ranges surveyed during the course of the study (Figure 7). While population size could not be estimated, our trapping results and aerial location data suggest that wolverines occur at low densities that may include only a few individuals per mountain range. Track detections for wolverines across all areas ranged from 39 to 115 detections during 3 years of landscape surveys. As previously mentioned, the variation in detection rates was influenced by our frequent travel of trap check routes in areas of known wolverine presence during 2002 and 2003, but we do not believe it represents any major change in wolverine abundance. Although we could not quantify the proportion of individuals that we captured in each population, we did design our trapping protocol to be intensive and widespread throughout the study area to provide a high probability of capturing all resident animals. Within each mountain range (Pioneers, Anaconda-Pintlers, and Flint Creek), adult males had home ranges that encompassed almost the entire range (Figure 2). Given that male home ranges tend to be exclusive (Banci 1987, Hornocker and Hash 1981, Magoun 1985), the number of mature males in each mountain range was very limited. We also know that females have overlapping home ranges and they often are encompassed by the home range of a single male (Magoun 1985). Approximately 33% of females successfully produce litters each year so the recruitment of young into these populations is low, as is the total number of individuals occupying these "island" mountain ranges (Persson 2003).

The notion that these mountain ranges support few individuals is further substantiated based on the reduced number of track detections following the removal of an individual. For

example, Bryant Creek located in the northwest Pioneers was a major source of wolverine detections during 2001 and 2002. However, track detections in this drainage were nearly absent in 2003 following the natural death of M3 (a subadult) and the harvest of M2 from this drainage that comprised a major portion of these animal's home ranges. Additionally, we found the number of wolverine crossing the Scenic Byway decreased sharply after the resident adult male was removed from the Pioneers.

Wolverine Population Connectivity

Mortality from trapping was the leading cause of mortality among our marked animals, and the high mortality rate reduced our ability to address project objectives. Other studies have also documented that human harvest is the leading cause of mortality (Krebs and Lewis 1999, Hornocker and Hash 1981). During our three year study, we had two instrumented and three non-instrumented animals harvested in our study area. The loss of one of these animals, a pregnant female, severely hindered our attempts to delineate wolverine denning habitat and recreational impacts on denning areas. The loss of the remaining 4 animals, all males, reduced our sample size and our ability to document dispersal movements and potential interactions with transportation corridors.

Although our data does suggest humans are the leading cause of mortality for this species, we did not document direct impacts from the Byway on this species. Krebs and Lewis (1999) reported that wolverine mortality due to collisions with vehicles was a leading cause of mortality in their Canadian study area. The size of this highway and its placement in a putative travel corridor for wolverine resulted in the high number of roadkills. In addition to actual vehicle/wolverine collisions, transportation corridors may impact wolverine populations by increasing isolation and reducing dispersal, but empirical data are lacking. Local community members reported seeing individual wolverines crossing both Highway 43 near Jerry Creek and Thompson's Corner, and Interstate 15 near Melrose, although no verification of these sightings exist. In addition, project telemetry documented the movement of M1 from the northwest Pioneers to the Anaconda-Pintler range and back again over the course of two weeks during 2002, but the exact highway crossing could not be documented (Figure 2). The low frequency of these documented crossings suggests that wolverines do occasionally move between mountain

ranges and cross major transportation corridors, but the landscape factors that affect these movements are unknown.

In addition to the risk of direct mortality related to transportation corridors, recent genetic research (Kyle and Strobeck 2002, Cegelski 2003) suggests that genetic structuring of southern wolverine populations in Idaho and Montana is occurring due to isolation of these populations from each other as well as from populations to the north. This isolation and lack of exchange of individuals between populations is important for two main reasons. First, dispersal and exchange of individual wolverines help to increase population sizes and increase the probability of persistence of that population. Second, exchange of individuals is necessary to facilitate gene flow, which in turn is necessary to prevent inbreeding effects and genetic differentiation of populations. While these effects may not be manifested in the short term, it is important to understand that isolation of southern populations is in fact occurring. Whether this is a result of the extirpation of subpopulations that has disrupted immigration/emigration dynamics, increased habitat fragmentation, barriers to dispersal, or the effects of other anthropogenic factors is unknown. However, these findings underscore the importance of managing landscapes in ways that maintain connectivity, and that additional research is needed to empirically define how wolverine respond to changes in landscape pattern.

Wolverine Habitat Use

The large home ranges of wolverines usually encompass a variety of habitat types. It is therefore not surprising that specific habitat preferences for wolverines have rarely been described. Rather, wolverine density appears to be influenced more by food availability and proximity to humans than to specific attributes of the habitat (Banci 1994). Hornocker and Hash (1981) suggested that wolverines selected for different elevation gradients throughout the year. However, analysis of our aerial locations using ArcGIS 8.3 digital elevation maps shows that wolverines did not appear to use elevation zones differently between seasons. Overlaying the calculated elevation zone on top of our study area showed that males used all elevations, while females appeared to live at slightly higher elevations and were not present in the lowest valley bottoms or drainages. However, the sample sizes for females (n=2) and males (n=4) are not adequate for determining if this difference is real or an artifact of small sample size. In contrast

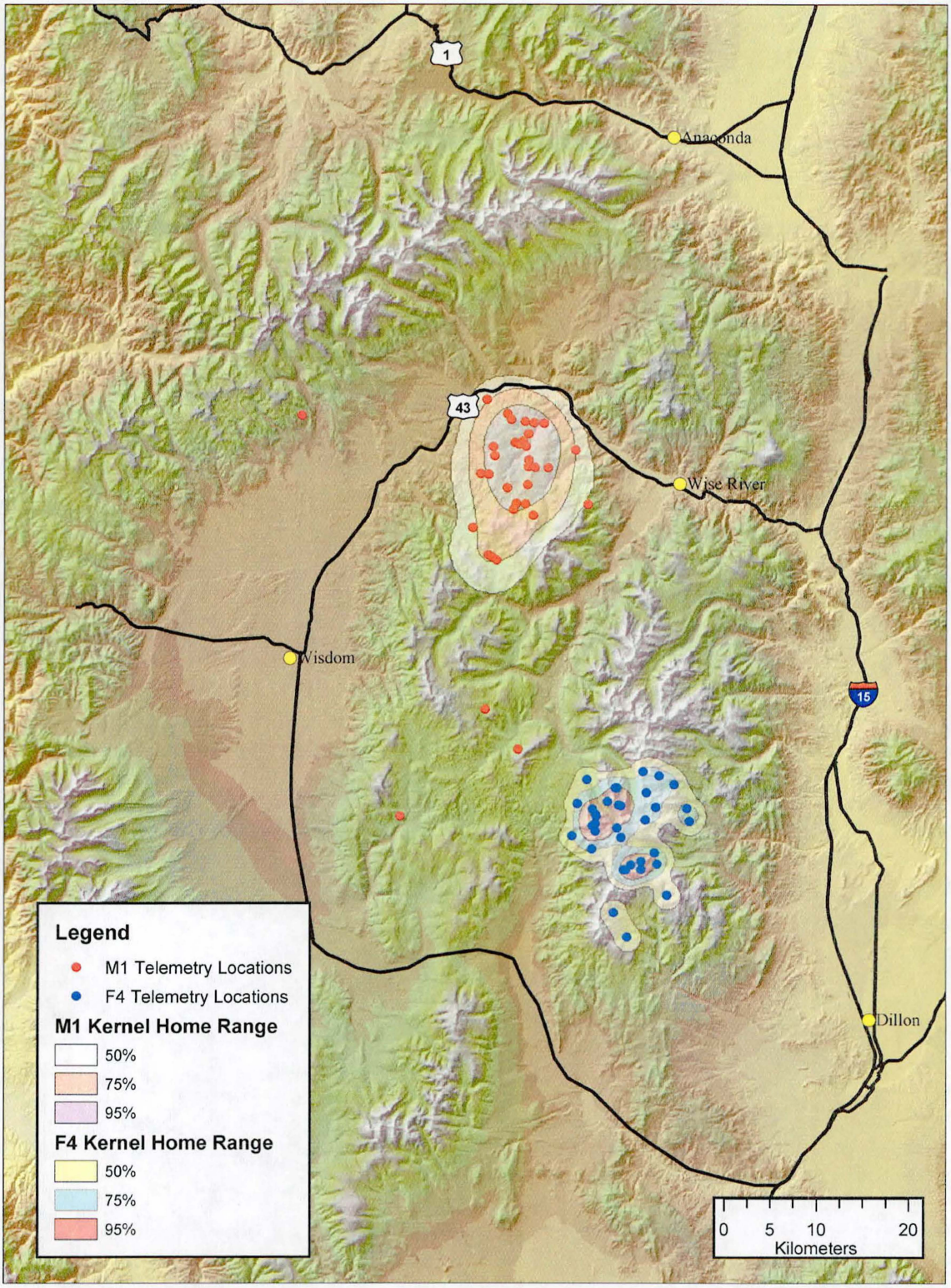

Figure 26: Fixed-Kernel home range estimates based on aerial locations for wolverines M1 (n=35) in the northwest Pioneers and F4 (n=35) in the eastern Pioneer Mountains.

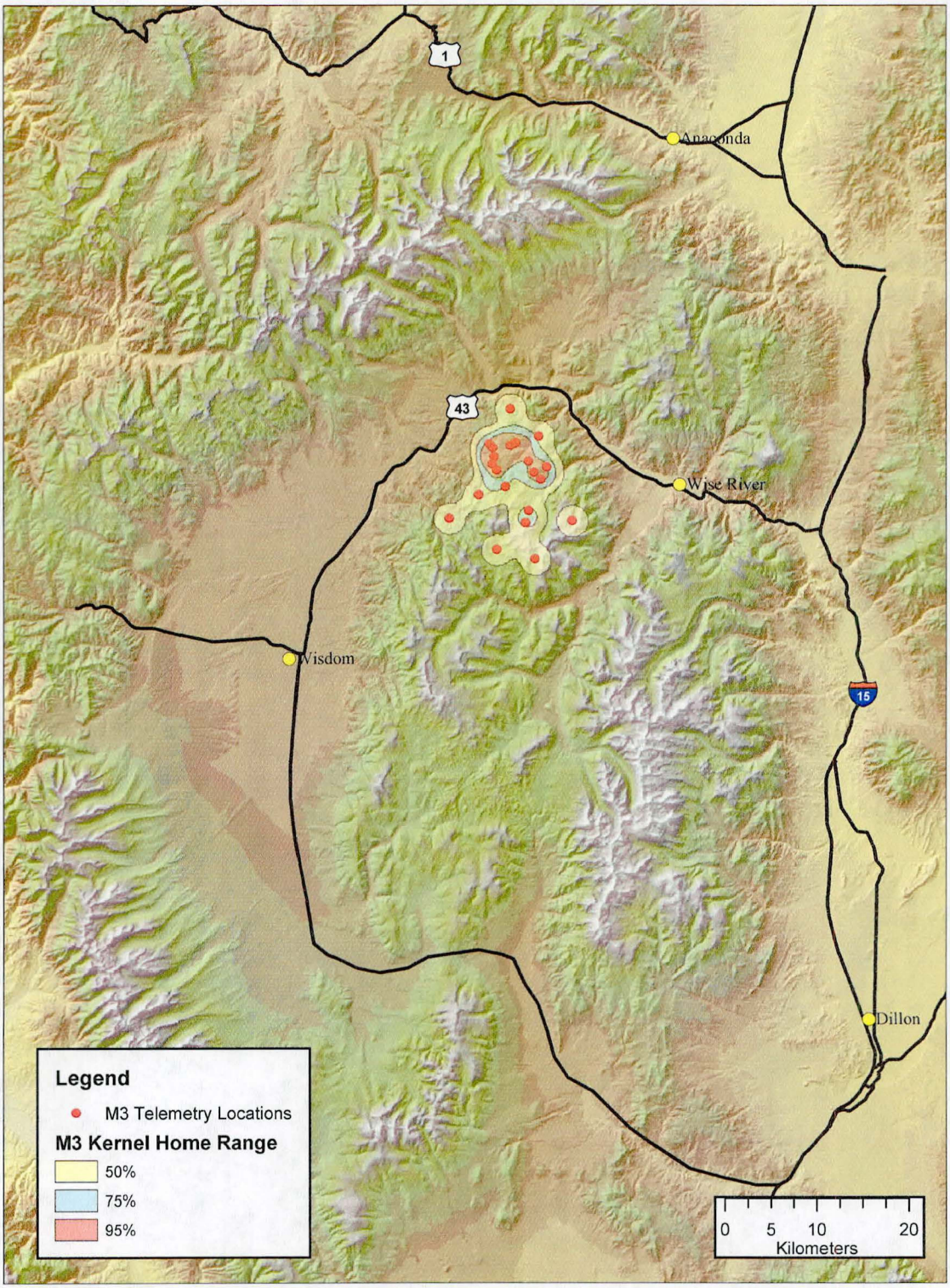

Figure 27: Fixed-Kernel home range estimate based on aerial locations for wolverine M3 (n=22) in the northwest Pioneer Mountains.

to other studies, wolverines in our study do not appear to shift elevation use between seasons due to temperature, food availability, or disturbance.

Since transportation corridors frequently occur in low elevation areas, combined with the fact that males typically range further than females, we believe that male wolverines have a higher likelihood of encountering transportation corridors than females. Although most females establish residency next to or within the natal home range (Magoun 1985), some immature females will disperse. Based on our elevation findings, it would be during these dispersal movements that females would be most likely to interact with transportation corridors.

Wolverine Home Range

The home ranges for adult males in the study area are comparable to the average home range size of 1525 km^2 found in Idaho (Copeland 1996). To put this in perspective, the home range of M2 (Figure 25) included the majority of the Pioneer Mountains, ranging from Bryant Creek in the northwest, down to Maverick Ski Hill in the South, and up to Vipond Park in the northwest Pioneers. Additionally, these animals are capable of traversing these large home ranges in a relatively short period of time. M2 was monitored and documented as having traveled between these three previously mentioned areas, a straight line distance of more than 90km, through steep topography within the course of 6 days. In another example, M5 in the Pintlers was located near Lost Trail Pass on the Idaho/Montana border one week, and was located in the northern Pintlers the next week. This is a straight line distance of 48 km traveled through the rough terrain of the Anaconda-Pintler Wilderness.

Given that adult male wolverines do not have overlapping home ranges, our home range results shed light on why wolverines occur at such low densities. The two sub-adult males (M1 and M3) captured in 2002 remained closely associated with each other throughout their first year (Figures 26-27). The home ranges of these two subadults overlapped each other's use area almost completely. Interestingly, these two individuals were often located together or traveling with M2. These findings suggest that M2 was the father and these two males were siblings; however, genetic results have not yet confirmed this theory.

Given that males range much more widely than females, we can predict that males should have a higher likelihood of interacting with travel corridors. While M1 was documented crossing Highway 43 and M2 repeatedly crossed the Scenic Byway, neither of the instrumented

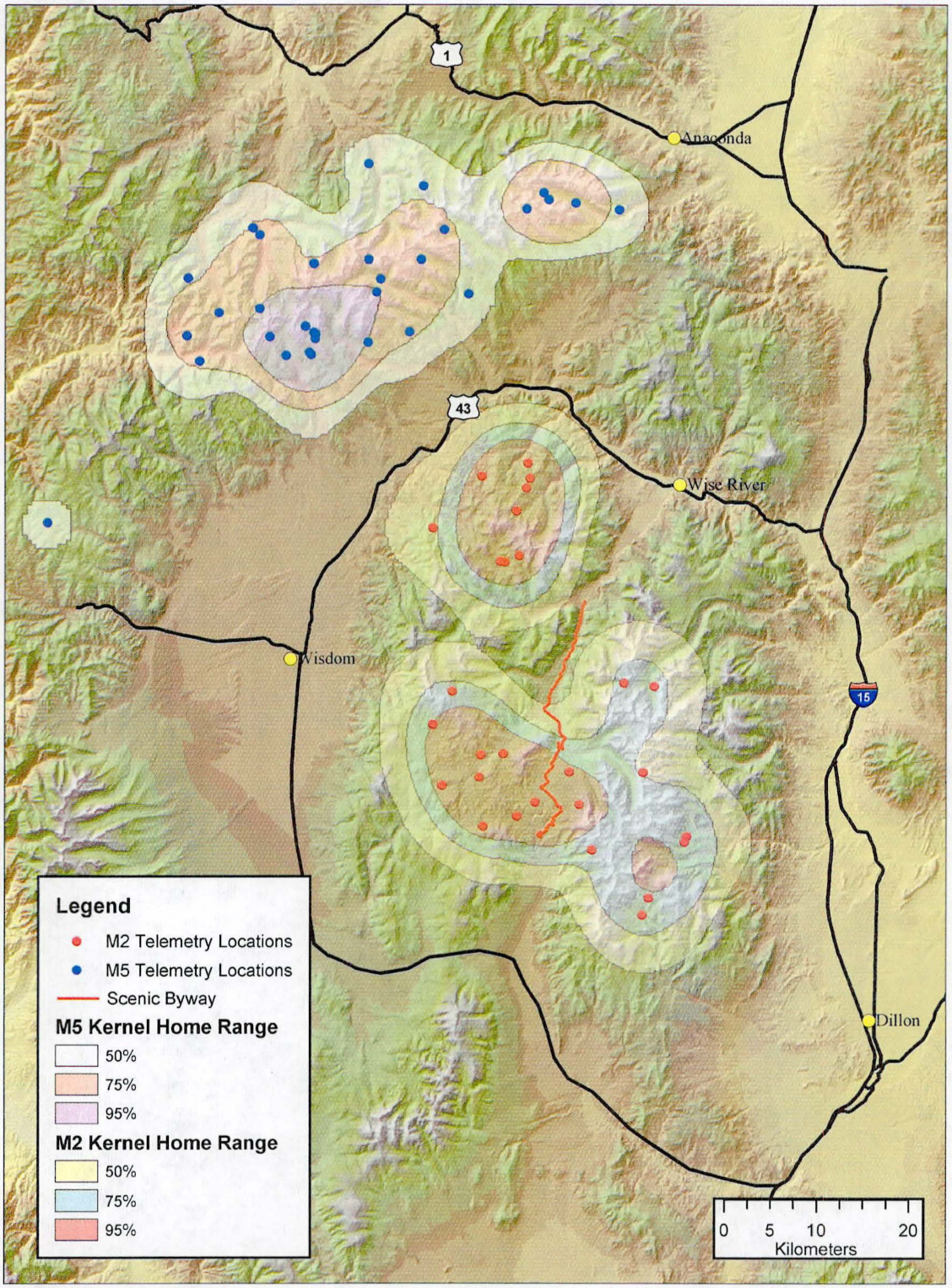

Figure 25: Fixed-Kernel home range estimates based on aerial locations for wolverines M5 (n=34) in the Pintlers and M2 (n=30) in the Pioneer Mountains relative to the Scenic Byway.

females have been documented crossing roads nor traveling any large distances. Long distance dispersal movements by wolverine appear to be driven by competition for resources and mates (Persson 2003). In Sweden, 100% of marked juvenile males and 69% of juvenile females dispersed during the study. However, individuals in vacant or abandoned territories did not disperse due to decreased competition. In the Pioneers, the high harvest rate of wolverines could severely impact the density of individuals, and therefore the intensity of competition. At about the time that two juvenile males, M1 and M3, were expected to disperse, M3 was killed by a predator and M2, the resident male, was killed by a trapper. The loss of these two animals would have made resources more abundant, which could potentially explain why we did not see any dispersal activity from the remaining juvenile wolverine (M1). The loss of other male wolverines in the study area during the same period decreased our ability to document dispersal activity among the populations. The frequent loss of animals results in vacant habitats and reduced competition for mates, which in turn reduces the need for dispersal. In sum, the high rate of loss of animals in the study area decreased our ability to study dispersal movements, which hindered our project in studying wolverine interactions with transportation corridors.

Pioneer Mountains Scenic Byway

The fact that we documented 15 wolverine crossings of the Scenic Byway during the three winters suggests that wolverine readily crossed the packed snowmobile trail. Our backtracking of wolverines as the approach the road provides anecdotal observations that support this conclusion (Figure 20-24). However, we cannot be certain of how many individual wolverines crossed the Byway. Given that wolverines live at very low densities with very large home ranges (1,445 km^2 for the resident male in the Pioneers and 178 km^2 for a resident female) that tend to be exclusive among individuals of the same gender (Magoun 1985), it is probable that the number of wolverine that cross the Byway is limited to relatively few individuals. This theory is supported by the fact that the harvest of M2, the resident Pioneer male, resulted in a sharp decrease in the number of documented crossings. Of the 5 study animals with calculated home ranges, only M2 had a home range that encompassed areas both east and west of the Byway (Figure 25). In addition, project trapping activities along the Byway failed to capture any additional animals during both 2002 and 2003, suggesting that there were no other resident

animals living adjacent to the Byway. Females F4 and F8 both have home ranges east of the byway, yet no telemetry locations to date have shown them crossing the Byway.

We should note that these crossing data relate specifically to the winter months in which the Byway is closed to wheeled vehicular traffic. Therefore, we cannot speak to changes in the use of habitats along the Byway during summer months when vehicles are present. We do know from seasonal telemetry location analysis that M2 used habitats on either side of the byway both during summer and winter, which is evidence that this individual wolverine crossed the byway during times when automobiles were present and the road surface was exposed, and during times when automobiles were absent and the road surface was snow-covered. However, we did find that 14 of 15 crossings occurred in forested areas along the Byway. The only exception was a wolverine traveling across the entire length of Crystal Park, an high-elevation grassland with a crossing distance of more than 500 meters. Crossings in forested areas were most common near Pattengail trailhead, the switchbacks at Mono Creek, and the higher elevation area near Goodenough Park. However, we could not statistically test this relationship due to the small sample size.

Other wildlife that frequently crossed the Byway during winter included martens (Figures 10 & 11) and coyotes (Figure 12 & 13), as well as snowshoe hares (*Lepus americanus,* Figures 14 & 15), red squirrels (*Tamiasciurus hudsonicus,* Figures 16 & 17) and moose (*Alces alces*, Figures 18 & 19). However, there were differences in where various species crossed and how they used the packed snow surface (Table 2). For example, coyote was the only species to use the road itself as an actual travel route based on track patterns. Martens, hares, squirrels, and ungulates typically only crossed the road.

Coyotes, snowshoe hares, and squirrels were the only species that appeared to be widely distributed along the entire length of the Byway, but hare densities were most high in the higher elevation fir forests on the south end of the Byway. Marten locations were concentrated in the higher elevation forests found along the southern portion of the Byway, while moose were most common in the lower elevation willow habitats found along the central part of the Byway. We could not test these habitat-use relationships during the summer because snow was absent.

While increased vehicular traffic along the Pioneer Mountains Scenic Byway was one of the major concerns regarding the road improvement projects, we were surprised to find that little monitoring has occurred or is planned to occur for documenting pre- and post-improvement

traffic. Our inquiries made to personnel at the U.S. Forest Service, Montana Department of Transportation, and Federal Highways Administration yielded limited information and it was beyond the scope of the project to monitor traffic volumes as they change seasonally.

GPS Collars

Subsequent to the 2001 field season, we recognized the need to use satellite technology to provide the frequent and steady data stream of locations necessary for delineating wolverine movements across landscapes and specifically in relation to transportation corridors. While ARGOS technology has been around for years, it typically has a large error radius of more than a kilometer, which makes it undesirable for fine-scale movement analysis. As a result, we chose to pursue GPS technology, which is accurate to within a few meters but typically requires a larger platform that needs to be recovered to retrieve data. Given that wolverines are wide-ranging species, we were hesitant to use GPS store-on-board technology for fear that we would be unable to recover the collar. Discussions with fellow wolverine researchers regarding the loss of wolverine collars substantiated our fears (Bob Inman, WCS, Personal Communication). In addition, discussions with wildlife satellite telemetry manufacturers prior to the 2002 field season indicated that available satellite platforms were too large and heavy for wolverine applications. As a result, we decided to use conventional VHF radio telemetry during the 2002 field season to address our objectives.

We continued to work with manufacturers and to stay abreast of developments in the technology throughout our study. By the summer of 2002, we located a vendor that indicated they could manufacture a GPS collar for wolverine that downloading all data on a daily basis through an ARGOS uplink. This ensured frequent data while removing the risk of losing the collar and the data it contained altogether. We worked with the company throughout the fall and early winter until we received our first GPS collars mid-winter, 2003. We were able to capture 3 large male wolverines during March of 2003 and to instrument them with these new GPS collars. Unfortunately, all three collars, as well as 4 other collars that we deployed on other study areas, failed within a week. While GPS technology continues to evolve at a rapid pace, it was not an available technology for the study. The failure to secure a workable GPS collar greatly impacted our ability to quantify wolverine movement relative to landscape pattern, especially during non-snow periods.

Summary

Our documentation that lynx are either absent or exceedingly rare in the Pioneer Mountains and adjacent ranges was the most pertinent result to highway planning. We acknowledge that lynx were present in these ranges in the recent past, but these populations did not persist. We also acknowledge that the status of lynx in the region may change if the area is repopulated from northern regions (McKelvey et al. 2000). Given that lynx were essentially absent during our study, we could not relate how improvements to the Scenic Byway would impact the local population.

We did document that wolverine were present in the Pioneer Mountains, Anaconda Range, and the Flint Creek Range. Wolverine crossed the Bypass during the winter when the unplowed road is a major snowmobile trail, and our limited backtracking studies indicated the individuals were not reluctant to cross the Byway based on their snow trails. We documented that a wolverine crossed Highway 43 as it moved between the Pioneer and Anaconda Mountain Ranges, but we were unable to provide precise details of where it crossed the highway. While collisions with vehicles may not be a major source of mortality for wolverine at low traffic volumes, transportation corridors (roads, urban development) may act as barriers to dispersal for these animals. Genetic research on wolverines has concluded that populations within Montana are becoming isolated from one another, which has major implication regarding population persistence of this species (Cegelski 2003). Unfortunately, it is difficult to quantify size of the transportation corridor or level of traffic that constitutes a barrier. In the case of the Scenic Byway and Highway 43, neither road appears to impair wolverine movements. In contrast, a study in British Columbia showed that large highways may act as major barriers and can cause significant mortality from road kill (Krebs and Lewis 1999). We were unable to rigorously quantify how wolverine responded to summer traffic on the Byway, because the GPS collars that were available during the study proved to be unreliable. However, we did provide anecdotal observations of a male wolverine crossing the Byway during the summer based on radio telemetry.

Based on trapping results, we believe that wolverine persist in these "island" ranges in very small populations that may include only a few individuals. Recreational trapping was the primary mortality factor for this population of wolverine. The high mortality of study animals

reduced our ability to address certain project objectives, such as providing observations of wolverine denning activity relative to the Byway.

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APPENDIX A:

Table 3. Habitat-use patterns of Coyote along the Pioneer Mountains Scenic Byway. * Denotes vegetation classes with differences at the .05 significance level, indicating selection for or against habitat components [1].

Classification	Expected proportion	Actual Proportion	Bonferroni intervals(-)	Bonferroni intervals(+)	Selected For	Selected Against
Land Cover						
Forest	0.788	0.910	0.858	0.963	*	
Shrubland	0.107	0.075	0.026	0.123		
Grassland	0.105	0.015	-0.007	0.037		*
Overstory Species						
Lodgepole	0.415	0.358	0.247	0.470		
Lodgepole / Doug Fir	0.144	0.269	0.166	0.372		
Mixed Spruce	0.039	0.090	0.023	0.156		
Mixed Subalpine	0.187	0.194	0.102	0.286		
Willow	0.107	0.075	0.014	0.136		
Aspen	0.003	0.003	-0.010	0.016		
Grass	0.105	0.015	-0.013	0.043		
Overstory Size Class						
Lg Log 12-20"	0.071	0.112	-1.181	1.405		
Sm Log 8-12"	0.695	0.769	-0.961	2.498		
Post 5-8"	0.022	0.030	-0.668	0.728		
No overstory	0.212	0.090	-1.081	1.260		*
Stand Structure						
Single Story	0.320	0.493	0.385	0.601	*	
2 Story	0.338	0.321	0.220	0.422		
Multi Story	0.130	0.097	0.033	0.161		
No overstory	0.212	0.090	0.028	0.151		*

[1] Chi-Square Goodness of Fit test with simultaneous Bonferroni confidence intervals.

Table 4. Habitat-use patterns of marten along the Pioneer Mountains Scenic Byway. * Denotes vegetation classes with differences at the .05 significance level, indicating selection for or against habitat components [1].

Classification	Expected proportion	Actual Proportion	Bonferroni intervals(-)	Bonferroni intervals(+)	Selected For	Selected Against
Land Cover						
Forest	0.788	0.991	0.969	1.013	*	
Shrubland	0.107	0.009	-0.013	0.031		*
Grassland	0.105	0.000	0.000	0.000		*
Overstory Species						
Lodgepole	0.415	0.389	0.263	0.515		
Lodgepole / Doug Fir	0.144	0.056	-0.004	0.115	*	
Mixed Spruce	0.039	0.046	-0.008	0.101		
Mixed Subalpine	0.187	0.500	0.371	0.629	*	
Willow	0.107	0.009	-0.016	0.034		*
Aspen	0.003	0.000	0.000	0.000		*
Grass	0.105	0.000	0.000	0.000		*
Overstory Size Class						
Lg Log 12-20"	0.071	0.111	0.036	0.187		
Sm Log 8-12"	0.695	0.861	0.778	0.944	*	
Post 5-8"	0.022	0.019	-0.014	0.051		
No overstory	0.212	0.009	-0.014	0.032		*
Stand Structure						
Single Story	0.320	0.315	0.203	0.427		
2 Story	0.338	0.537	0.417	0.657	*	
Multi Story	0.001	0.139	0.056	0.222	*	
No overstory	0.212	0.009	-0.014	0.032		*

[1] Chi-Square Goodness of Fit test with simultaneous Bonferroni confidence intervals.

Table 5. Habitat-use patterns of snowshoe hare along the Pioneer Mountains Scenic Byway. * Denotes vegetation classes with differences at the .05 significance level, indicating selection for or against habitat components [1].

Classification	Expected proportion	Actual Proportion	Bonferroni intervals(-)	Bonferroni intervals(+)	Selected For	Selected Against
Land Cover						
Forest	0.788	0.879	0.842	0.917	*	
Shrubland	0.107	0.075	0.045	0.105		*
Grassland	0.105	0.046	0.022	0.070		*
Overstory Species						
Lodgepole	0.415	0.314	0.255	0.374		*
Lodgepole / Doug Fir	0.144	0.098	0.060	0.136		*
Mixed Spruce	0.039	0.027	0.006	0.048		
Mixed Subalpine	0.187	0.440	0.376	0.503	*	
Willow	0.107	0.046	0.019	0.072		*
Aspen	0.003	0.000	0.000	0.000		
Grass	0.105	0.075	0.041	0.109		
Overstory Size Class						
Lg Log 12-20"	0.071	0.159	0.116	0.203	*	
Sm Log 8-12"	0.695	0.670	0.614	0.726		
Post 5-8"	0.022	0.050	0.024	0.076		
No overstory	0.212	0.121	0.082	0.160		*
Stand Structure						
Single Story	0.320	0.203	0.155	0.251		*
2 Story	0.338	0.230	0.180	0.280		*
Multi Story	0.176	0.446	0.387	0.506	*	
No overstory	0.212	0.121	0.082	0.160		*

[1] Chi-Square Goodness of Fit test with simultaneous Bonferroni confidence intervals.

Table 6. Habitat-use patterns of red squirrel along the Pioneer Mountains Scenic Byway. * Denotes vegetation classes with differences at the .05 significance level, indicating selection for or against habitat components [1].

Classification	Expected proportion	Actual Proportion	Bonferroni intervals(-)	Bonferroni intervals(+)	Selected For	Selected Against
Land Cover						
Forest	0.788	0.986	0.973	1.000	*	
Shrubland	0.107	0.011	-0.001	0.024		*
Grassland	0.105	0.002	-0.003	0.008		*
Overstory Species						
Lodgepole	0.415	0.400	0.337	0.464		
Lodgepole / Doug Fir	0.144	0.233	0.179	0.288	*	
Mixed Spruce	0.039	0.066	0.034	0.098		*
Mixed Subalpine	0.187	0.286	0.228	0.344	*	
Willow	0.107	0.011	-0.002	0.024		*
Aspen	0.003	0.000	0.000	0.000		
Grass	0.105	0.002	-0.004	0.008		*
Overstory Size Class						
Lg Log 12-20"	0.071	0.072	0.014	0.130		
Sm Log 8-12"	0.695	0.664	0.558	0.770		
Post 5-8"	0.022	0.016	-0.012	0.044		
No overstory	0.212	0.248	0.151	0.345		
Stand Structure						
Single Story	0.320	0.456	0.345	0.567	*	
2 Story	0.338	0.368	0.260	0.476		
Multi Story	0.130	0.000	0.000	0.000		*
No overstory	0.212	0.176	0.091	0.261		

[1] Chi-Square Goodness of Fit test with simultaneous Bonferroni confidence intervals.

Table 7. Habitat-use patterns of moose along the Pioneer Mountains Scenic Byway. * Denotes vegetation classes with differences at the .05 significance level, indicating selection for or against habitat components [1].

Classification	Expected proportion	Actual Proportion	Bonferroni intervals(-)	Bonferroni intervals(+)	Selected For	Selected Against
Land Cover						
Forest	0.788	0.752	0.659	0.845		
Shrubland	0.107	0.248	0.155	0.341	*	
Grassland	0.105	0.000	0.000	0.000		*
Overstory Species						
Lodgepole	0.415	0.424	0.305	0.543		
Lodgepole / Doug Fir	0.144	0.216	0.117	0.315	*	
Mixed Spruce	0.039	0.048	-0.003	0.099		
Mixed Subalpine	0.187	0.064	0.005	0.123		*
Willow	0.107	0.248	0.144	0.352	*	
Aspen	0.003	0	0	0	*	
Grass	0.105	0	0	0		*
Overstory Size Class						
Lg Log 12-20"	0.071	0.072	0.014	0.130		
Sm Log 8-12"	0.695	0.664	0.558	0.770		
Post 5-8"	0.022	0.016	-0.012	0.044		
No overstory	0.212	0.248	0.151	0.345		
Stand Structure						
Single Story	0.320	0.456	0.345	0.567	*	
2 Story	0.338	0.368	0.260	0.476		
Multi Story	0.130	0.000	0.000	0.000		*
No overstory	0.212	0.176	0.091	0.261		

[1] Chi-Square Goodness of Fit test with simultaneous Bonferroni confidence intervals.

Library -

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